IMPROVING FORECASTS OF RUNOFF

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INTRASEASONAL HYDROLOGIC FORECASTS

Generate an archive of atmospheric forecasts

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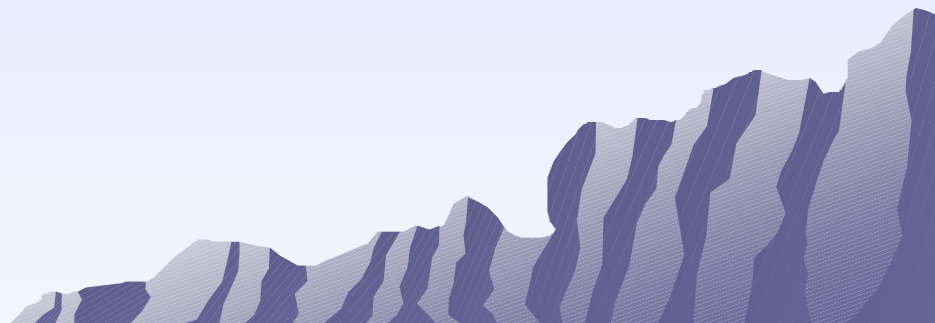

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Run hydrologic models in ensemble mode to provide probablistic forecasts of streamflow and estimates of forecast uncertainty

❑ Perform side-by-side comparisons with operational NWS forecasts, and, where appropriate, infuse our procedures in regular NWS operations

MRF FORECAST ARCHIVE

- **The NCEP/NCAR reanalysis –**

  a 40+ year record of global atmospheric fields and surface fluxes derived from a numerical weather prediction and data assimilation system kept unchanged over the analysis period

- **Every five days, a single realization of an 8-day forecast was run**

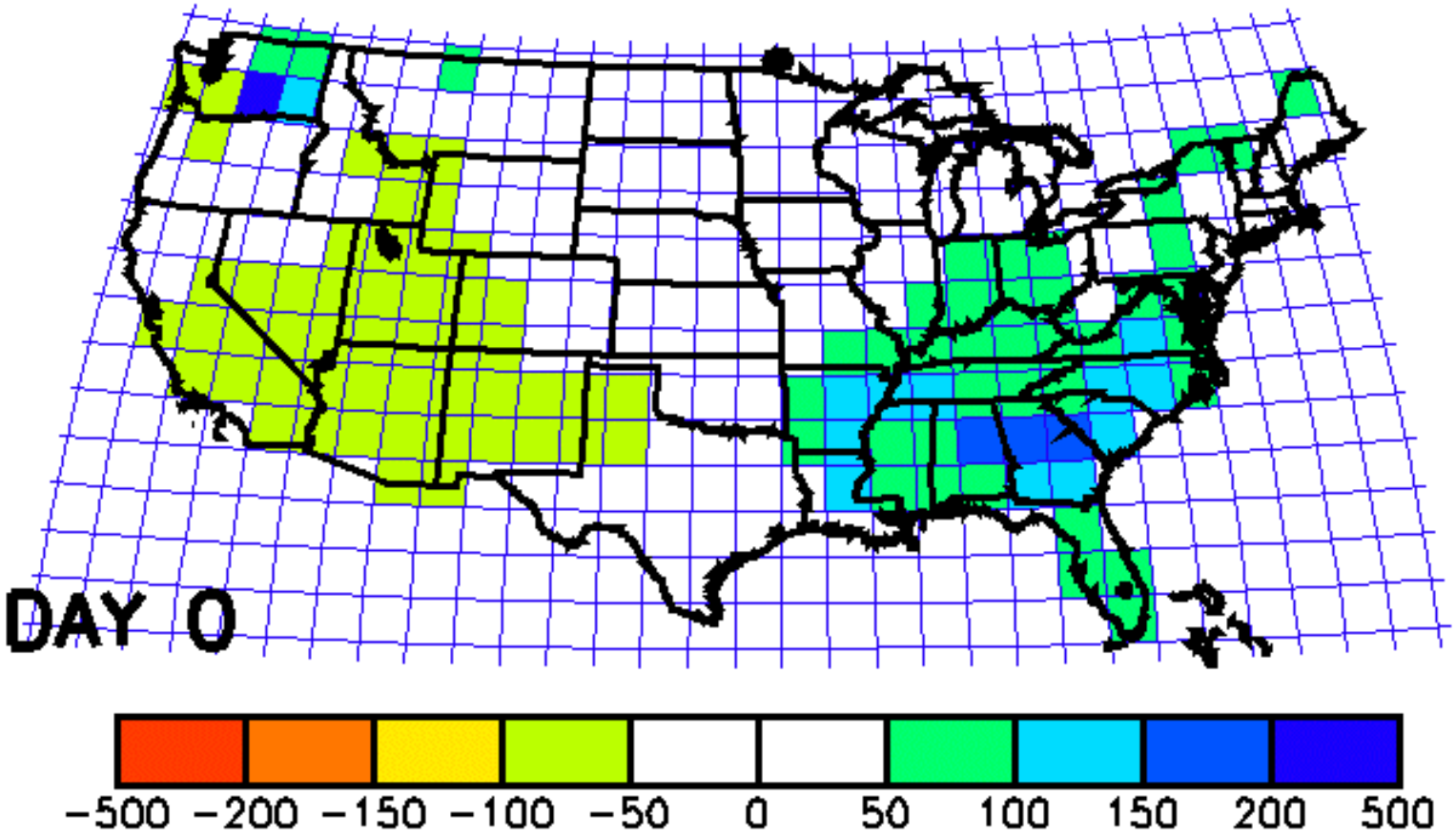
  for the period 1958-1998, this provides over 2500 8-day forecasts that can be compared with observations

- **Model output is archived on a regular lat/lon grid with approx 1.875° horizontal resolution.**

INTRASEASONAL HYDROLOGIC FORECASTS

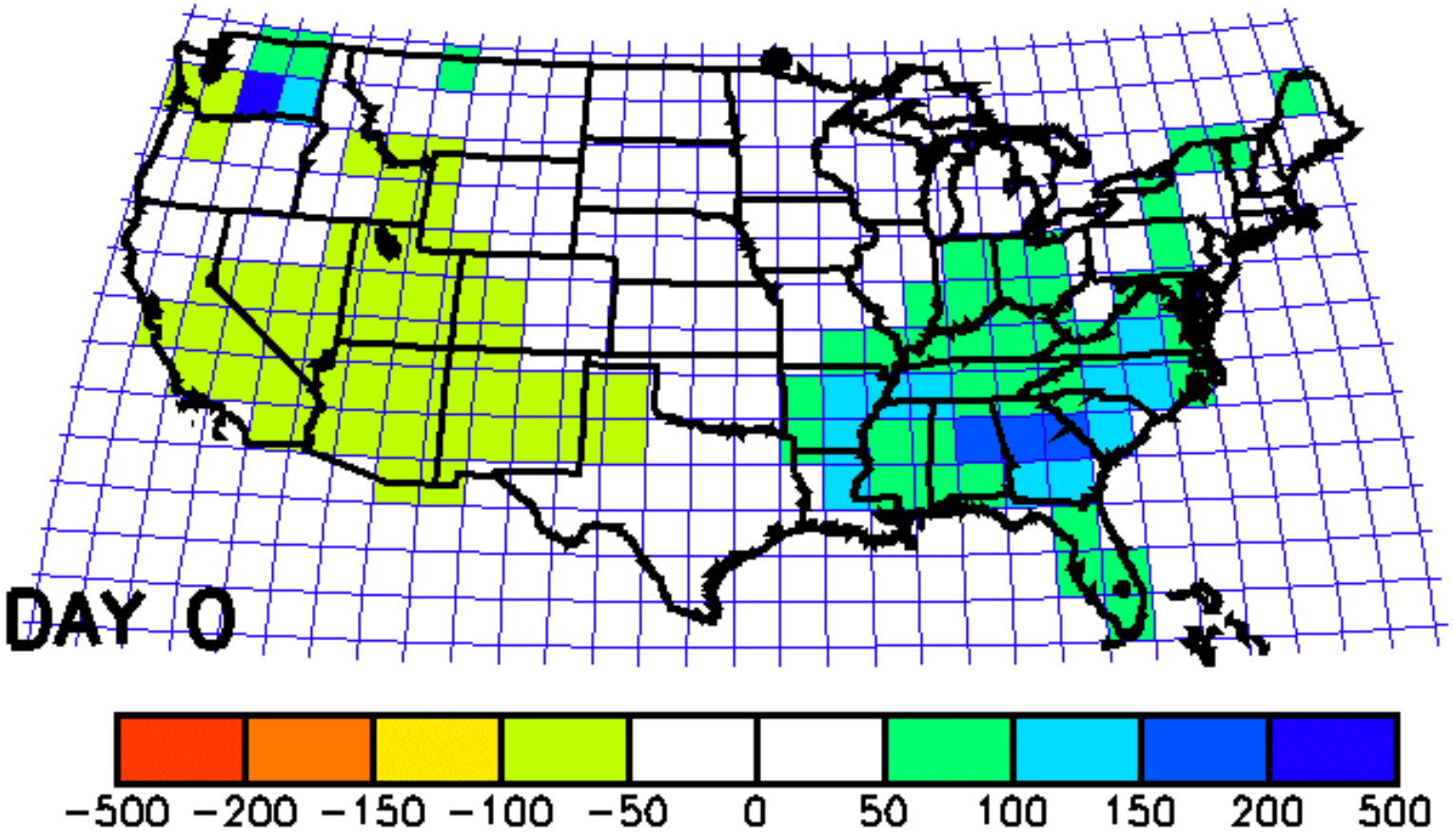
Generate an archive of atmospheric forecasts

THE NEED FOR A FIXED NWP MODEL

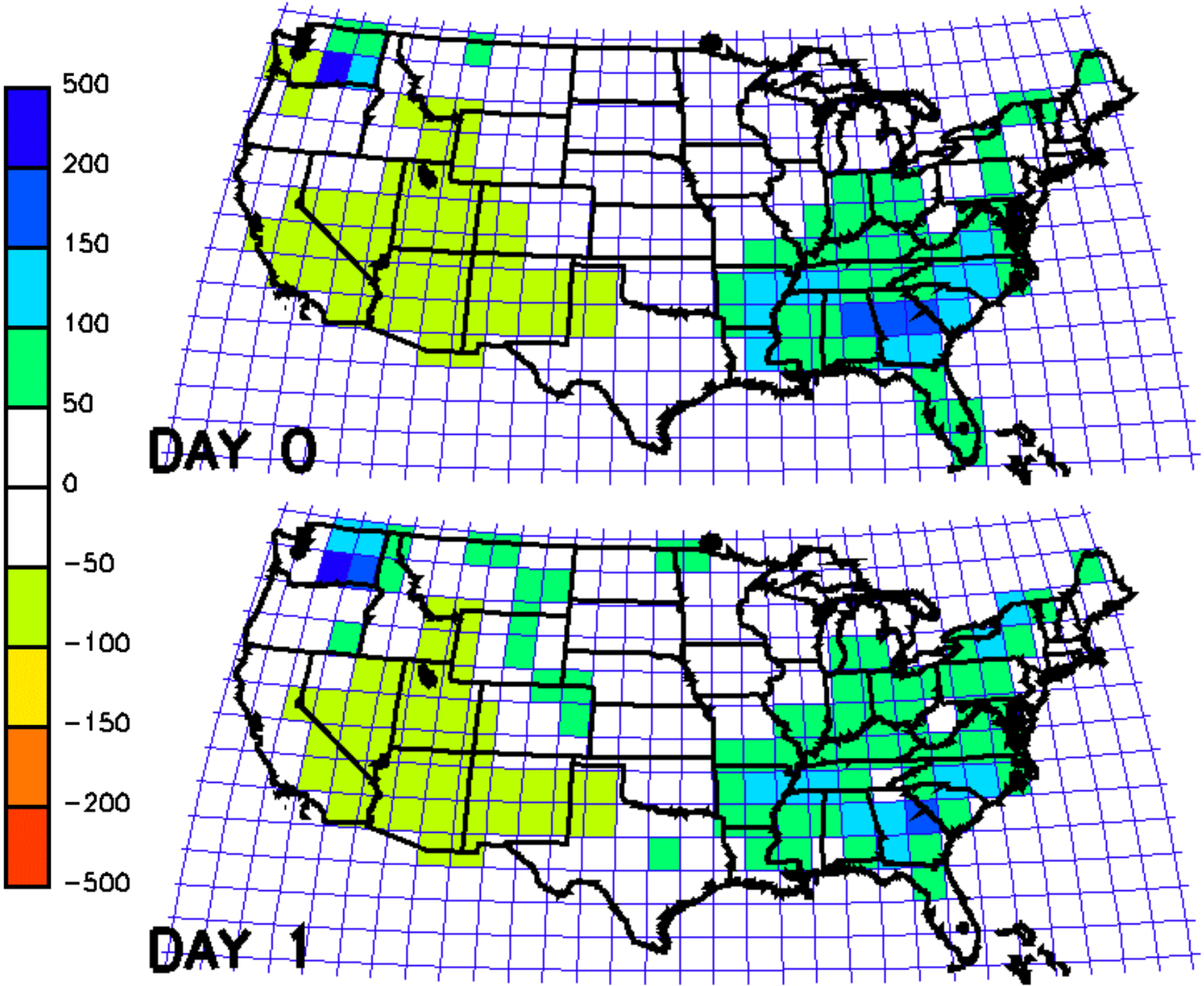


- Model July precipitation biases (% mean) in the NCEP/NCAR reanalysis

THE NEED FOR A FIXED NWP MODEL



Precipitation biases are in excess of 100% of the mean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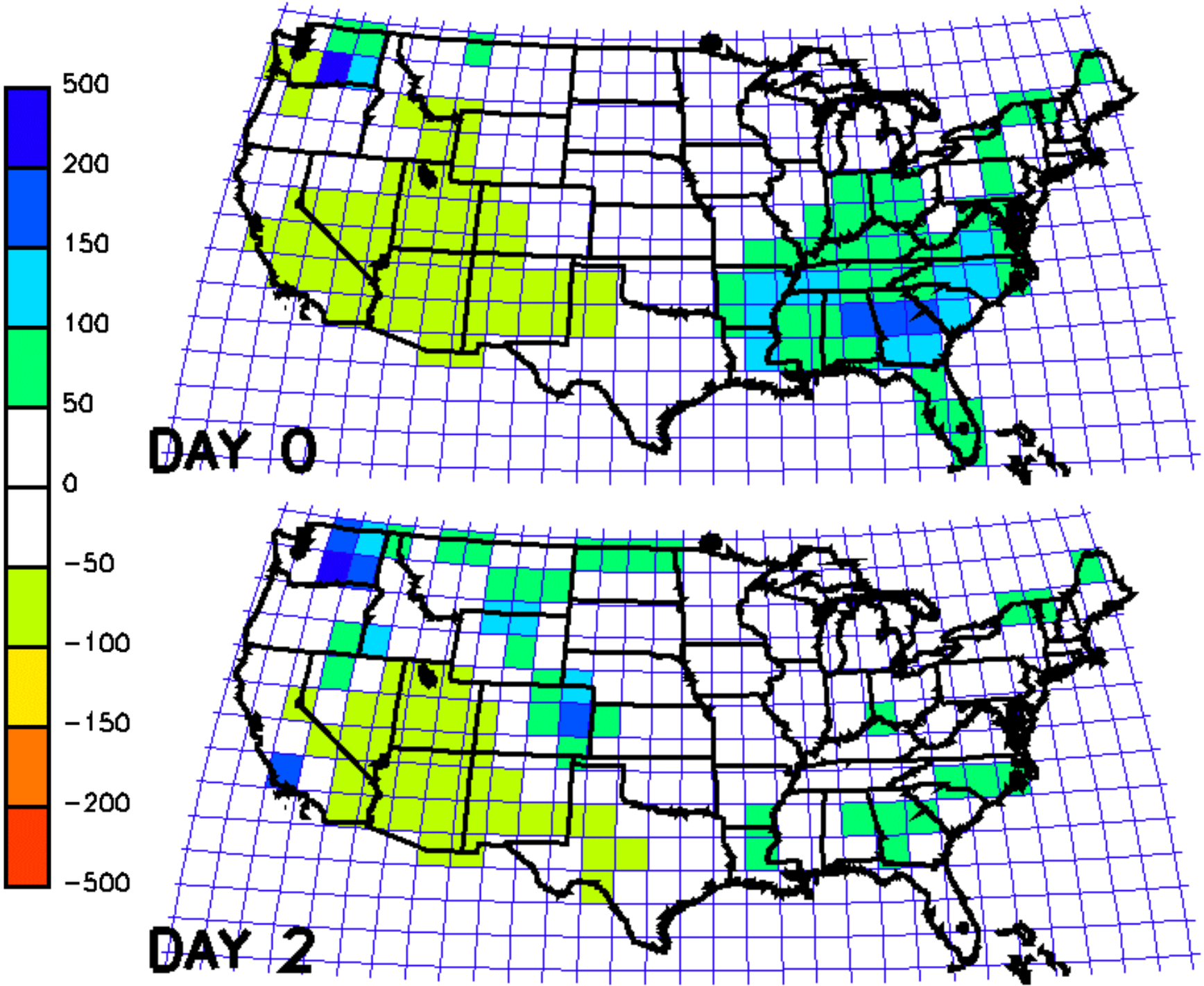
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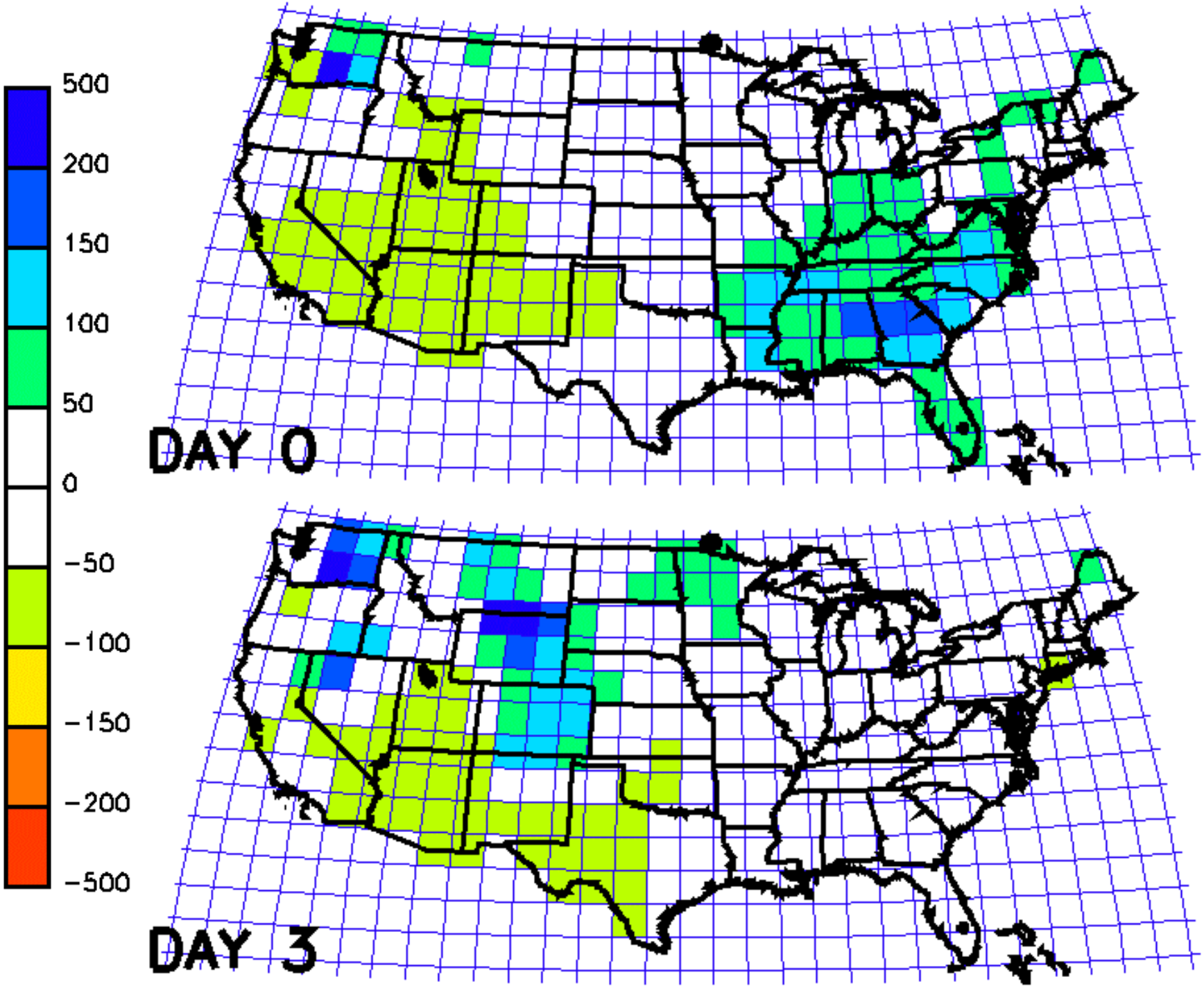
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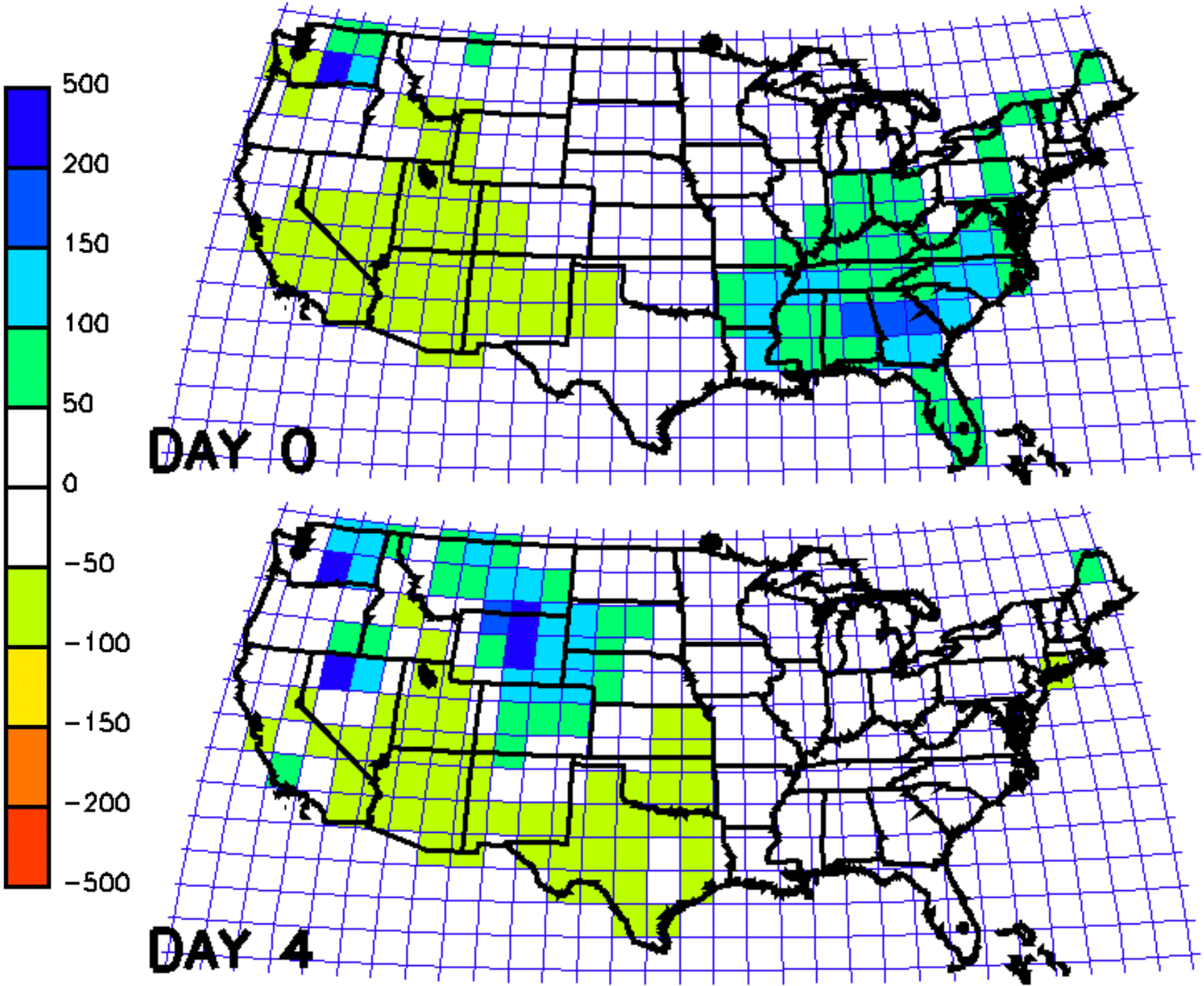
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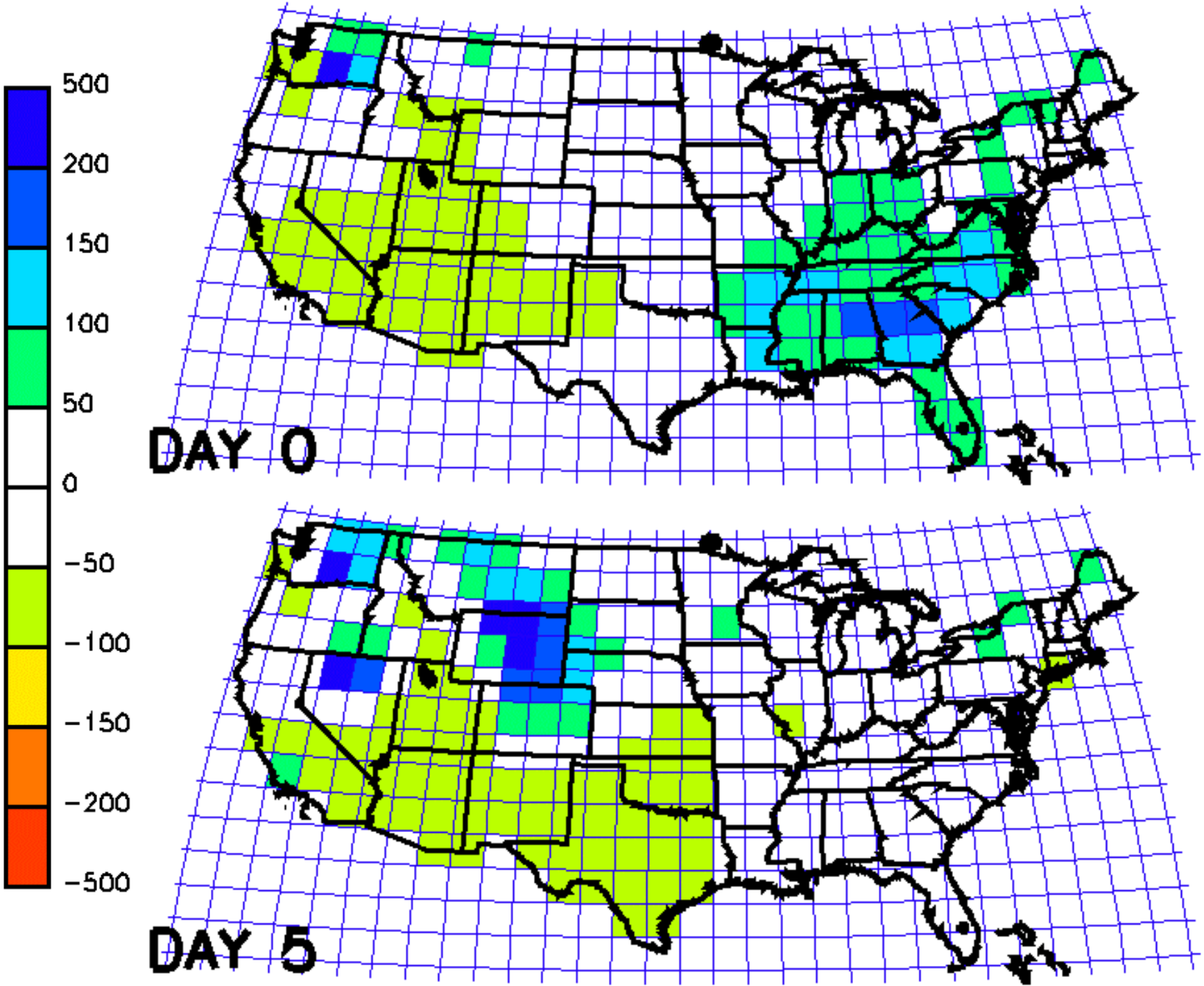
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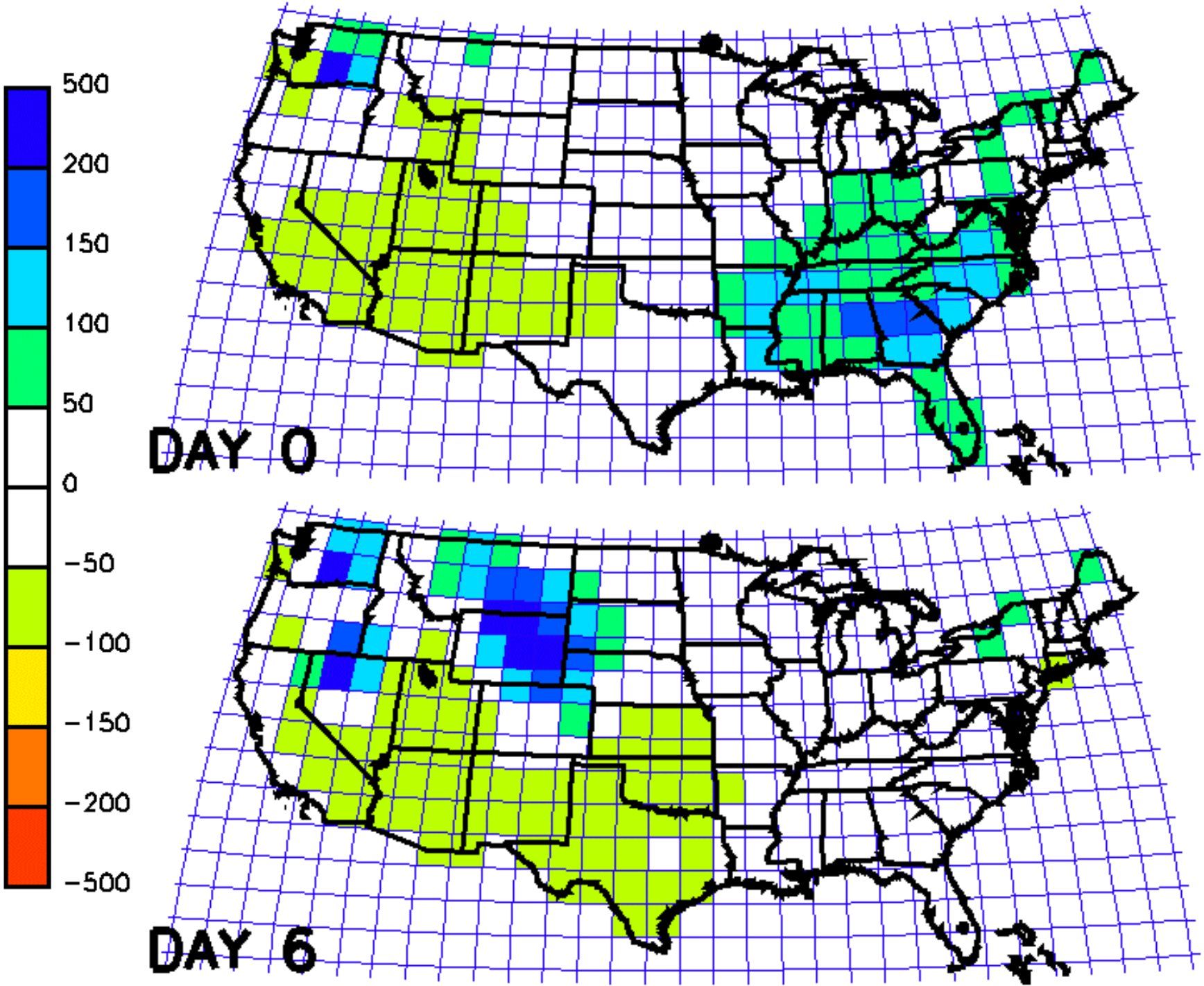
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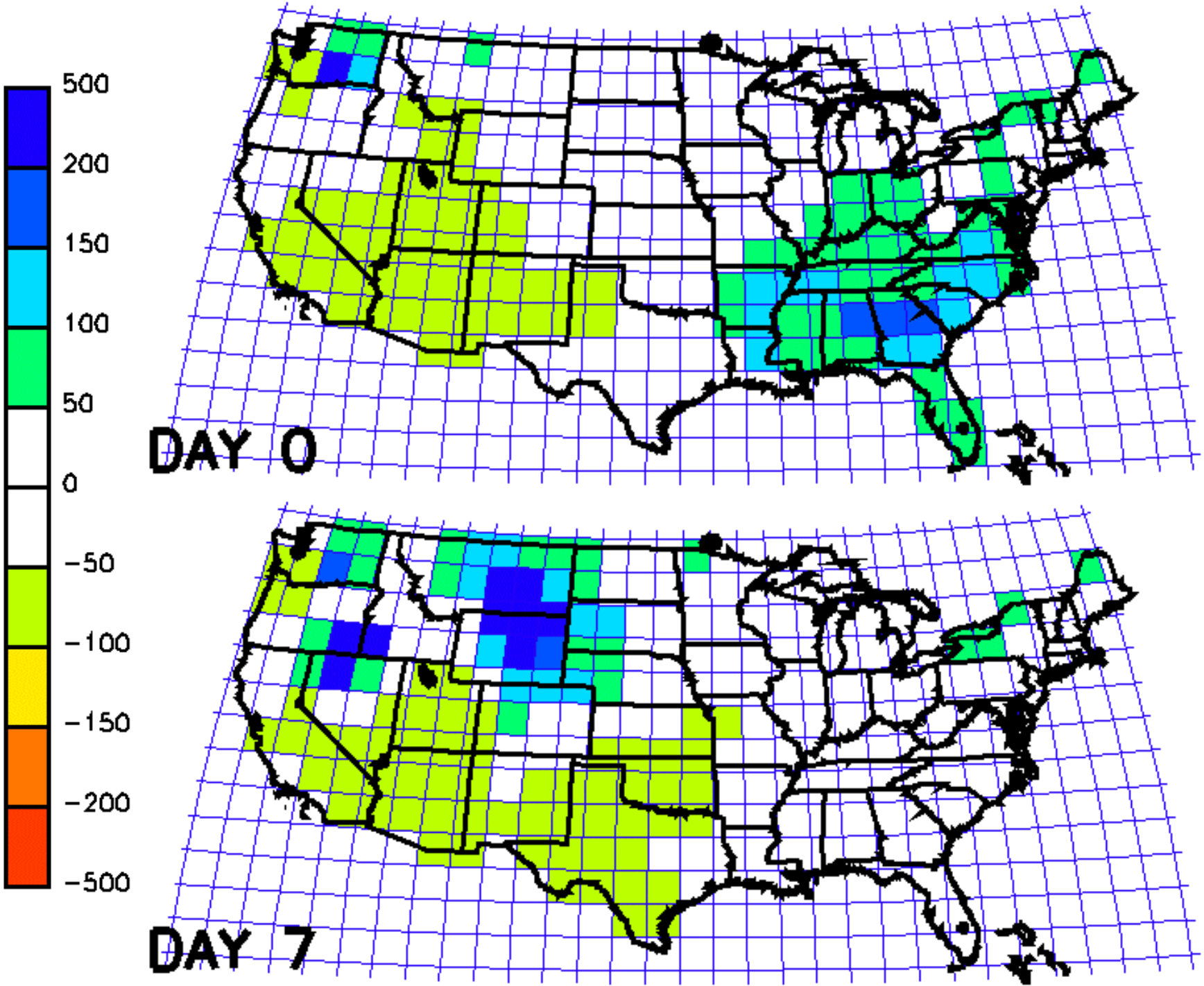
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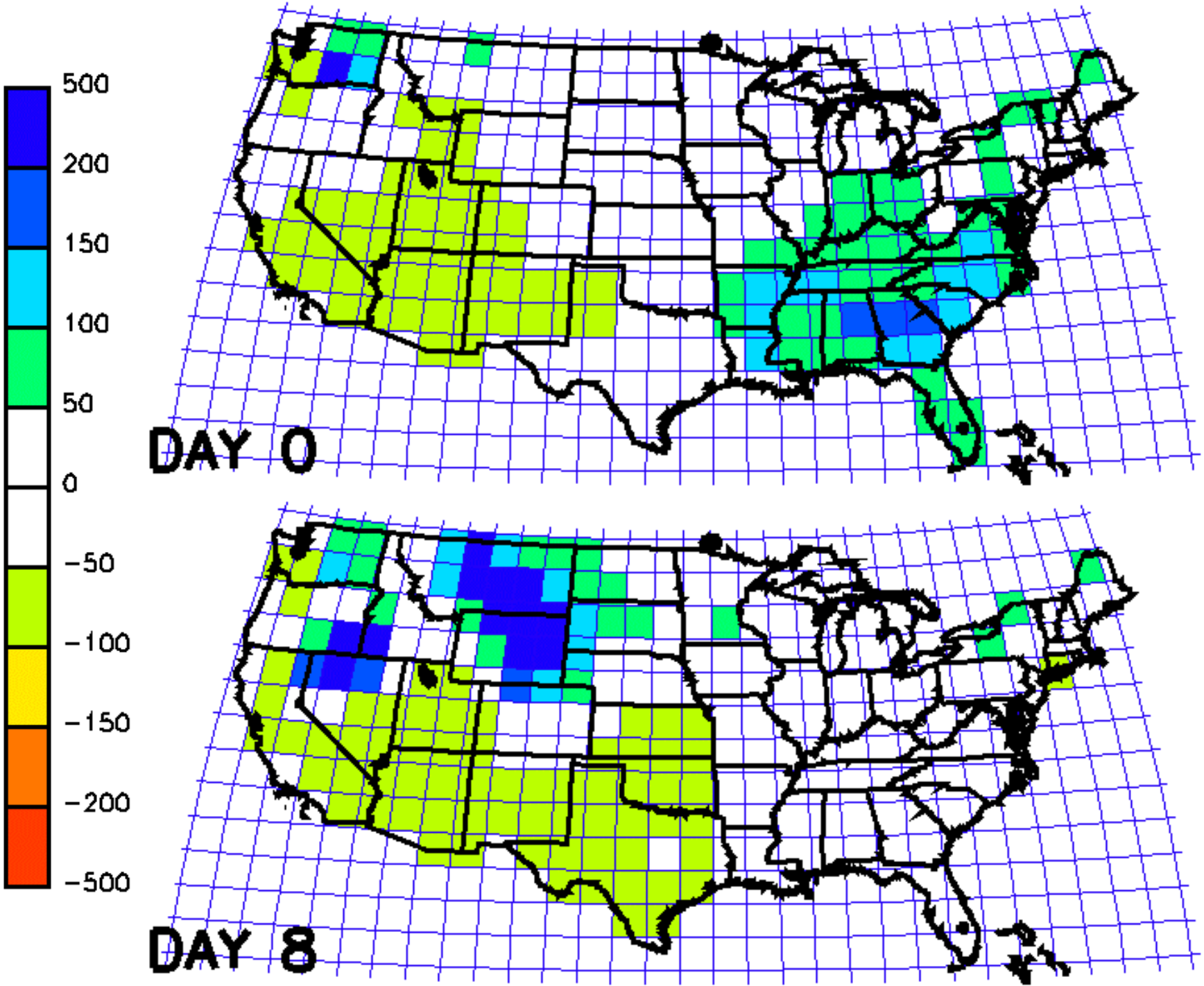
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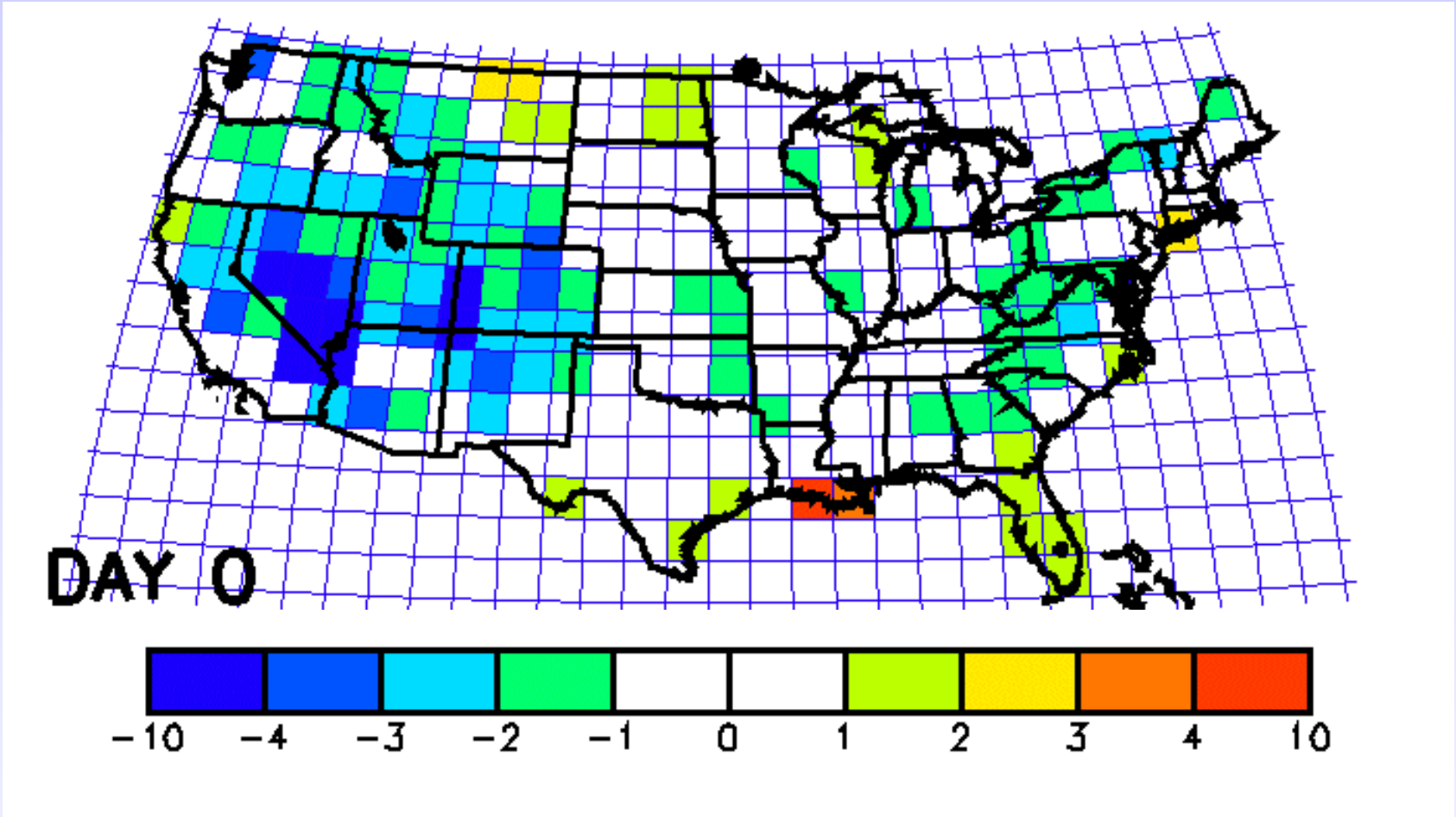
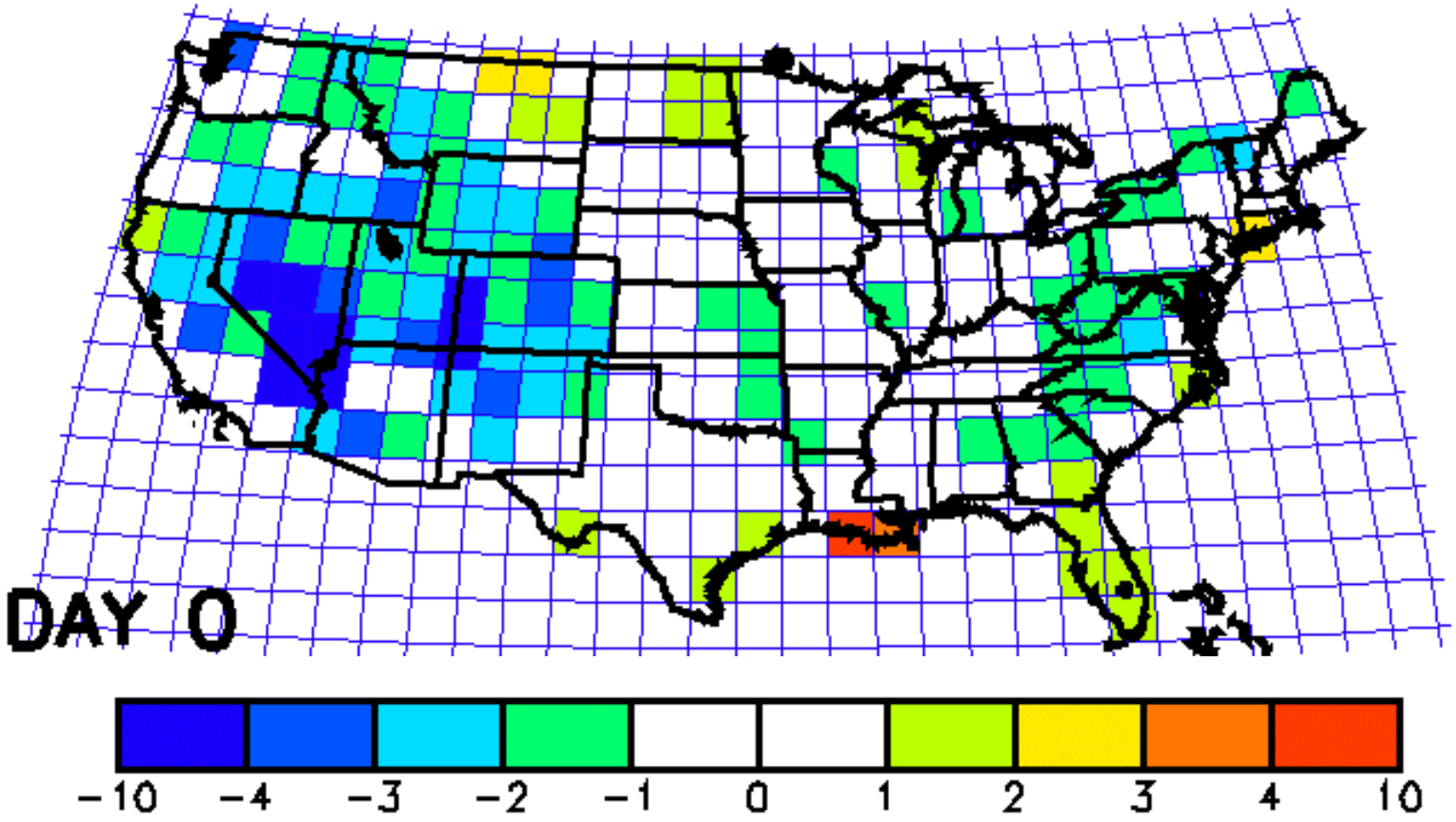
TEMPERATURE BIASES

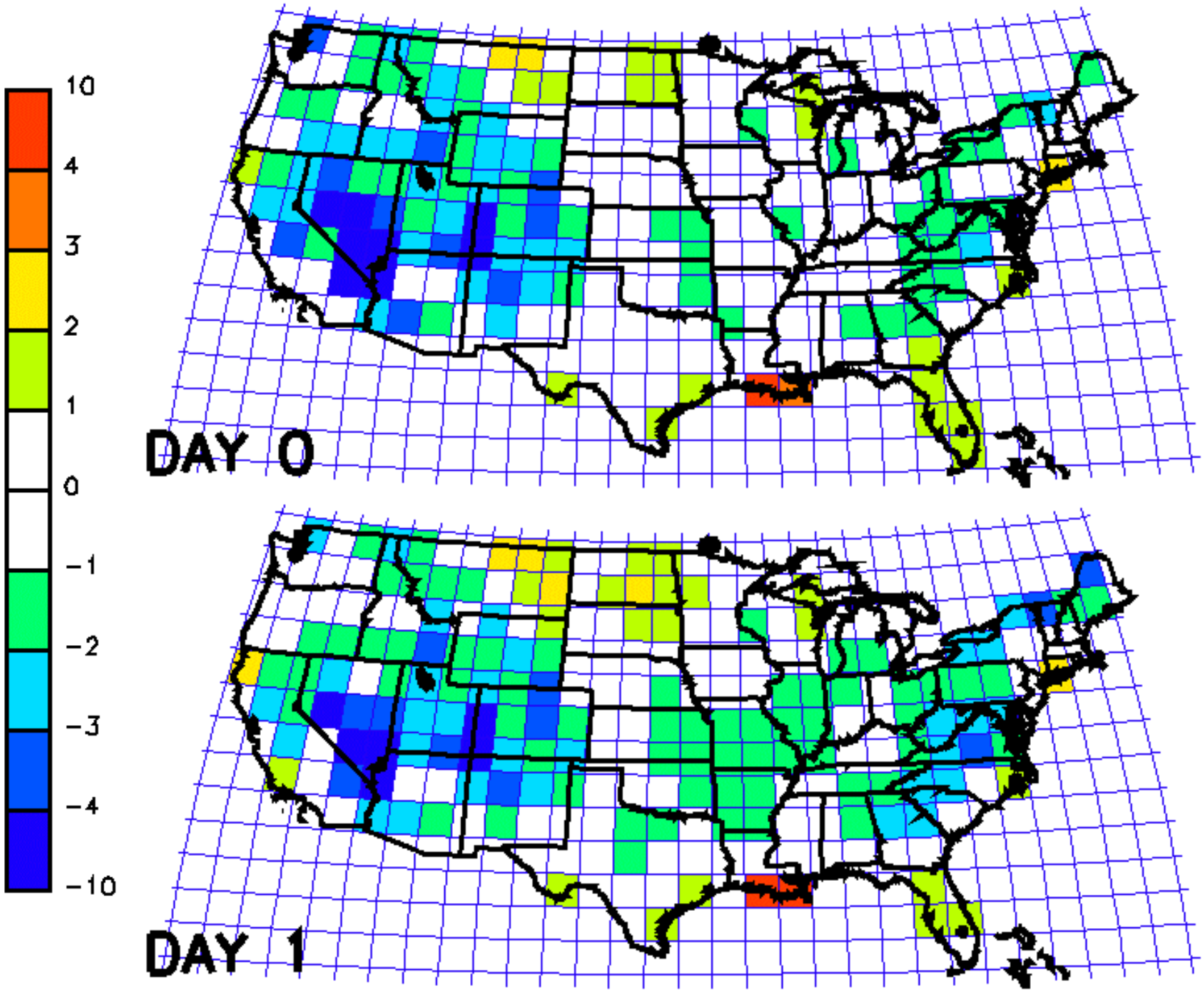


❑ Model January temperature biases (°C) in the NCEP/NCAR reanalysis

TEMPERATURE BIASES



Temperature biases are in excess of 3°C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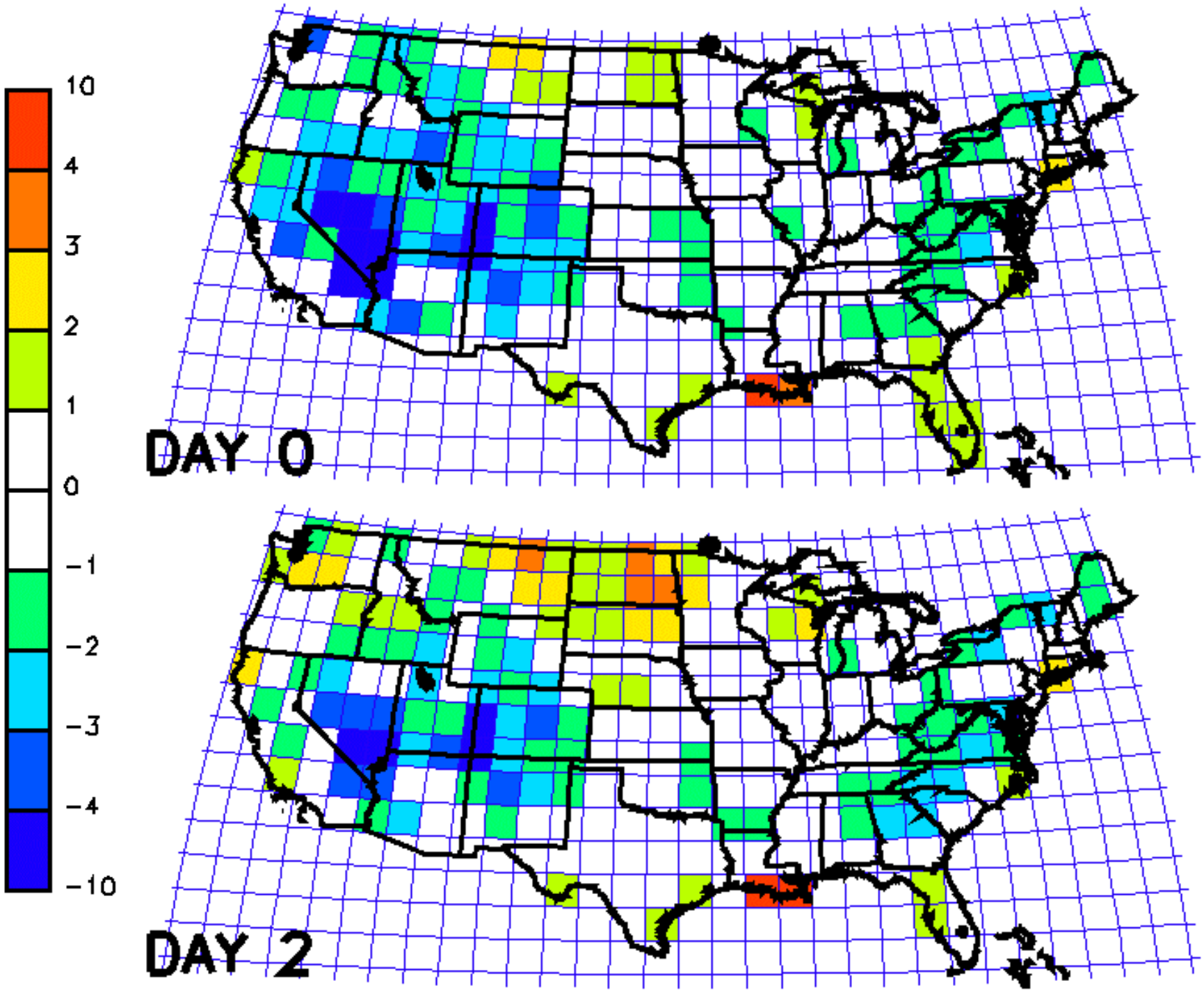
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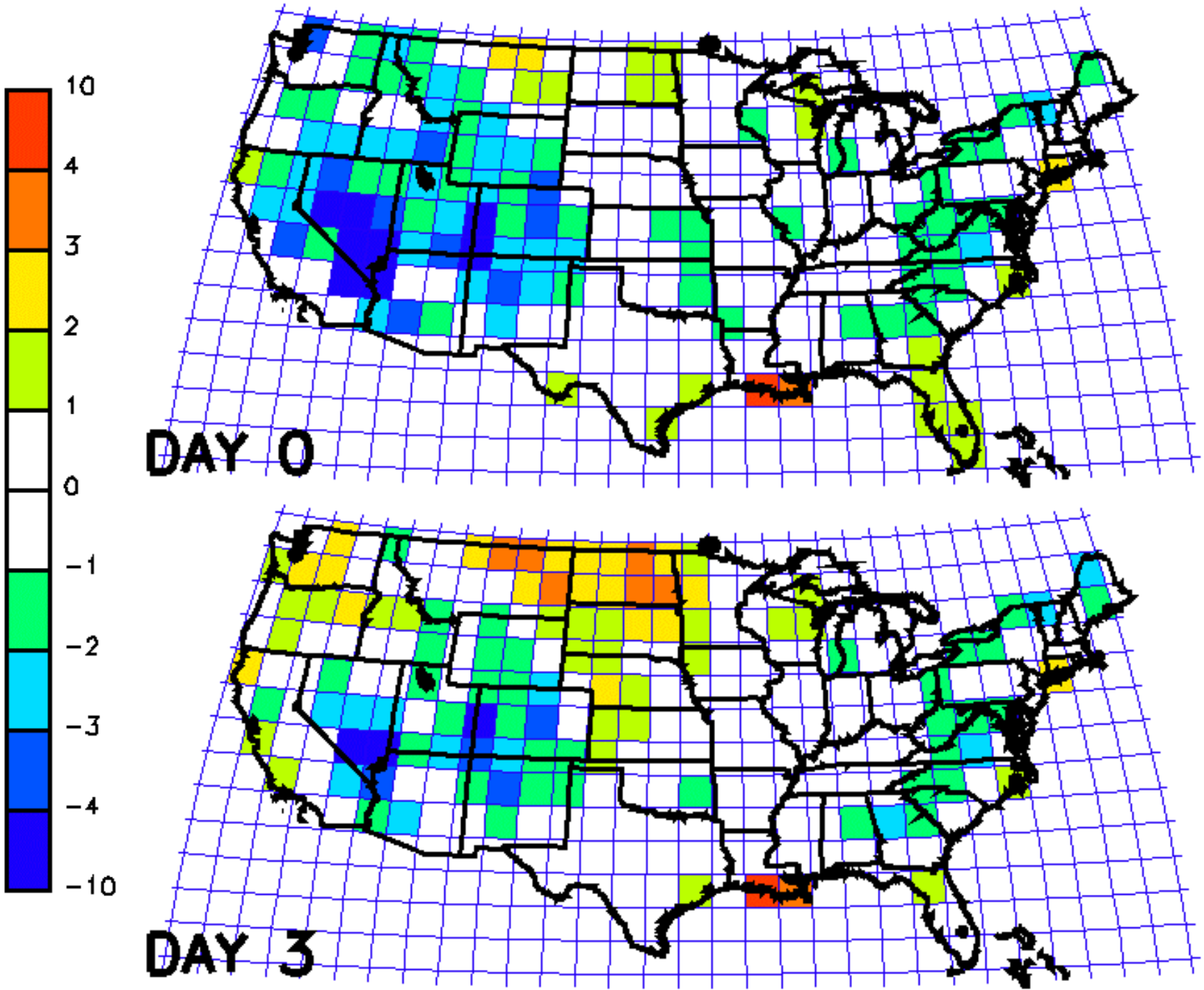
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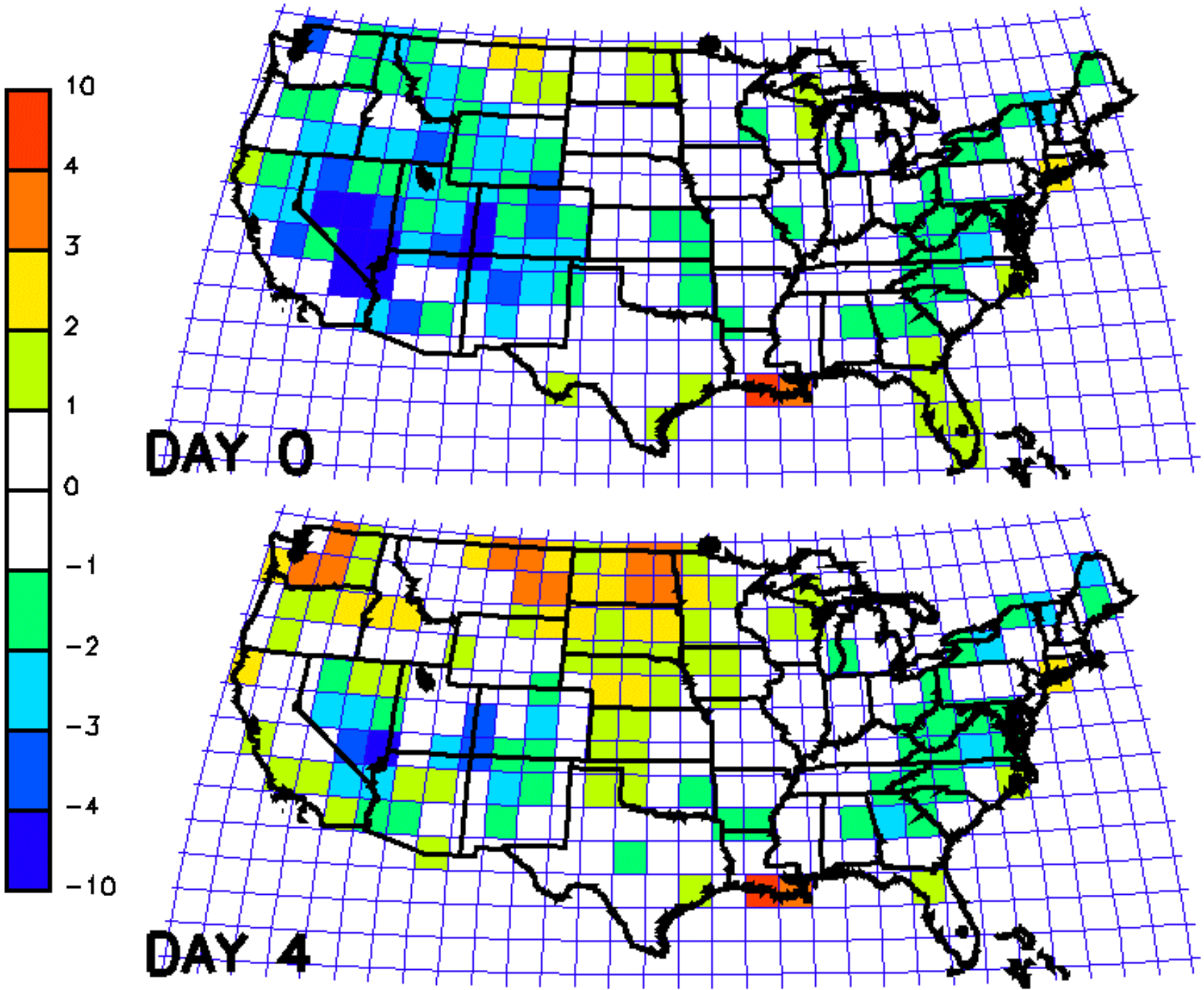
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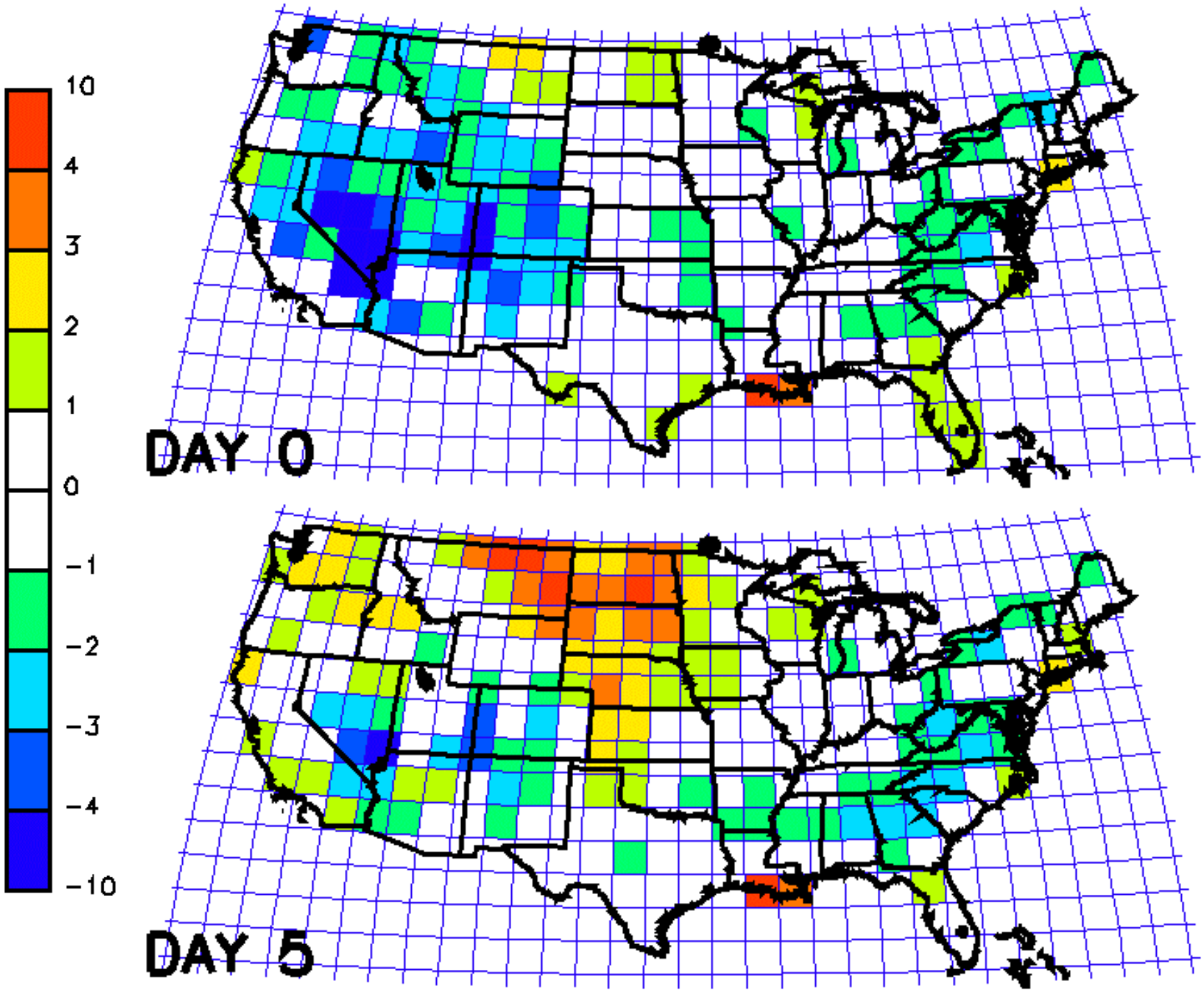
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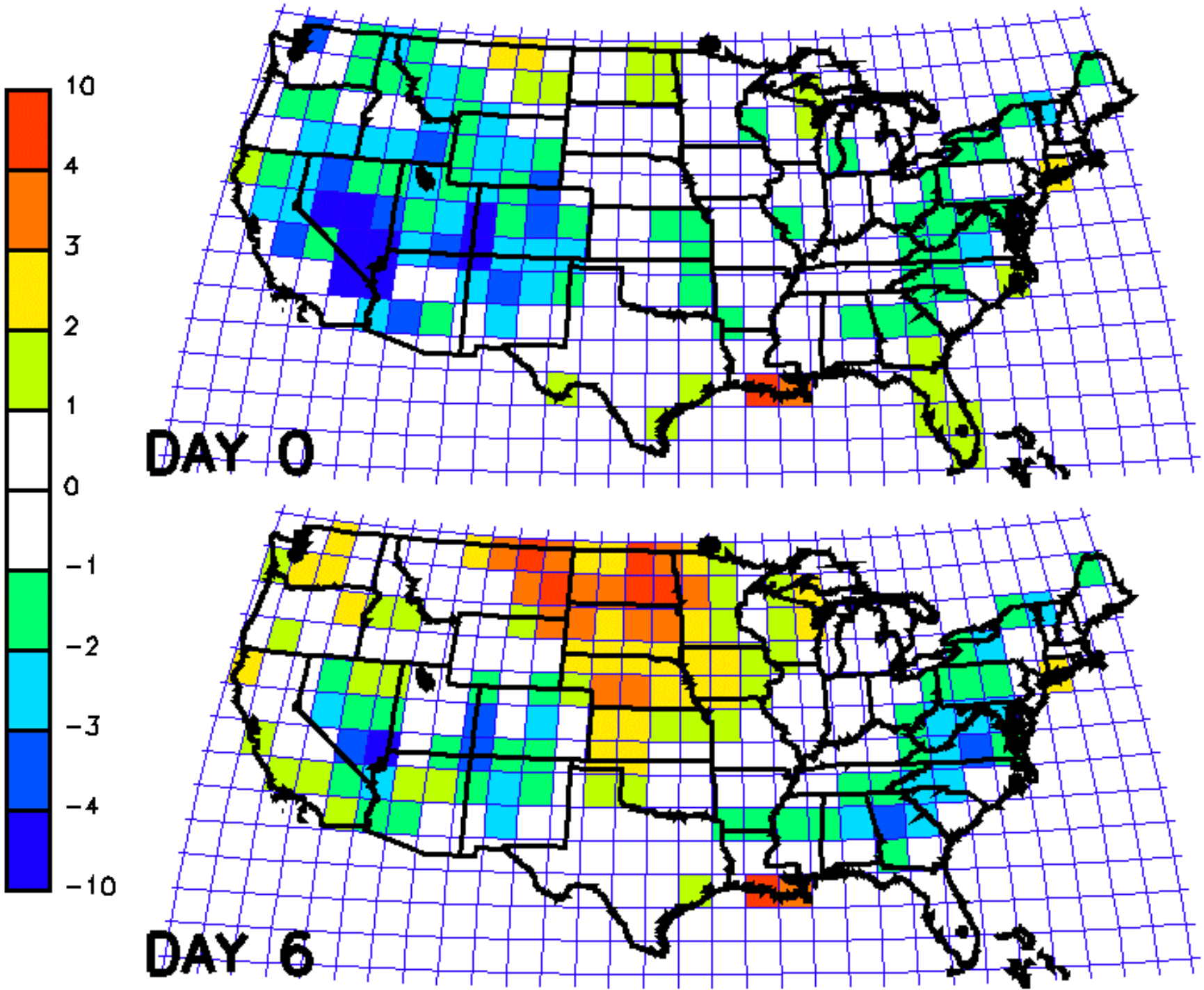
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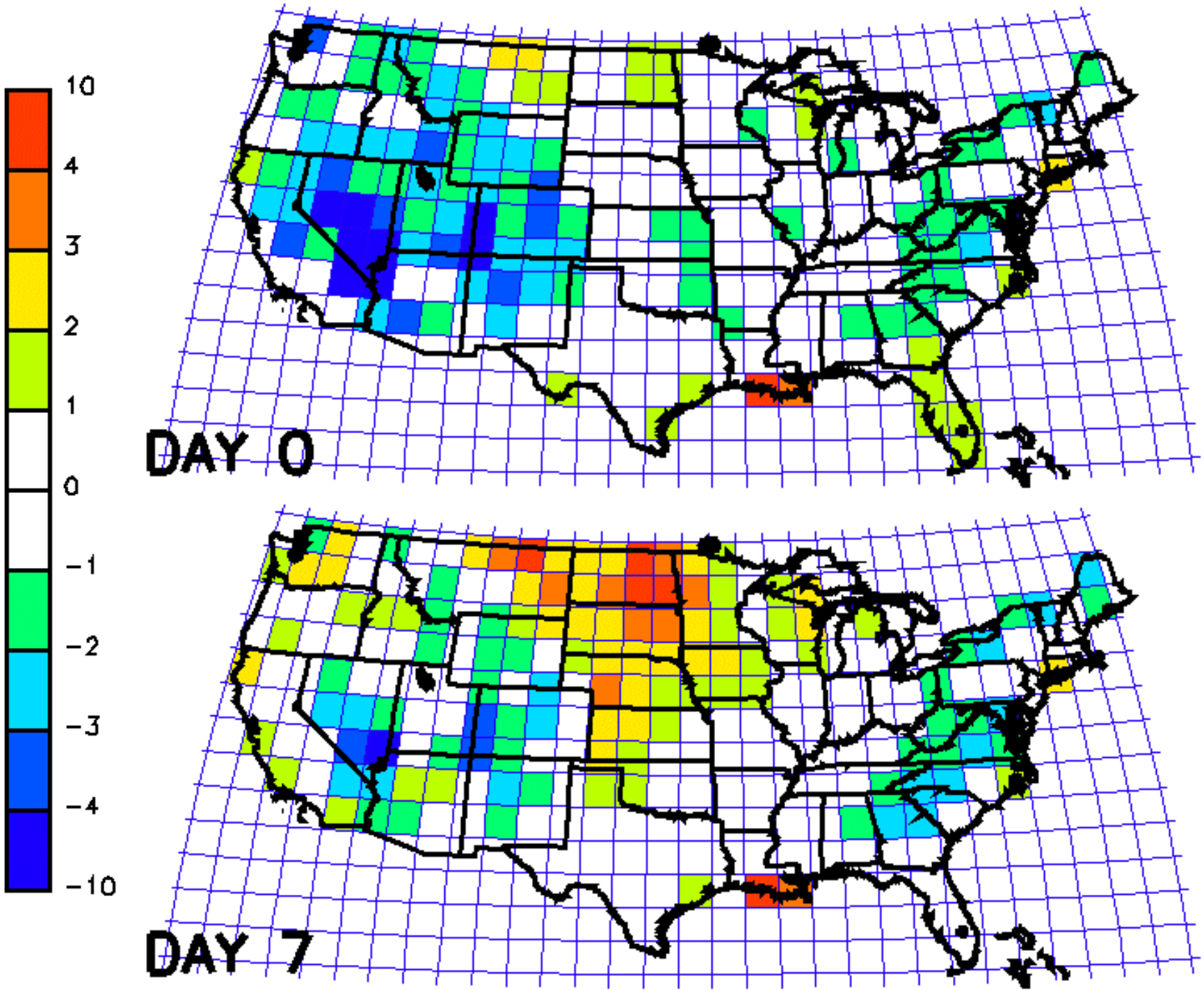
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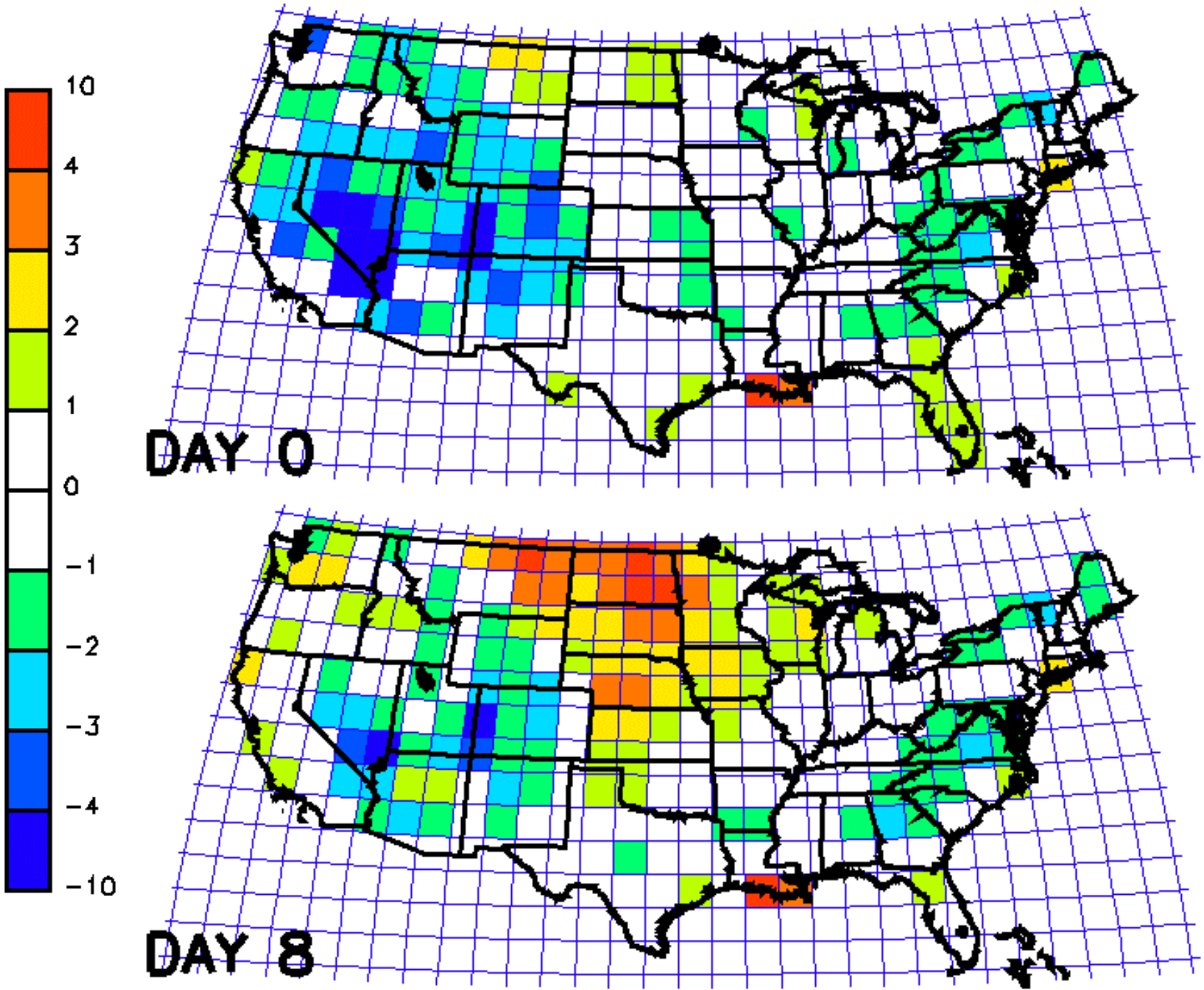
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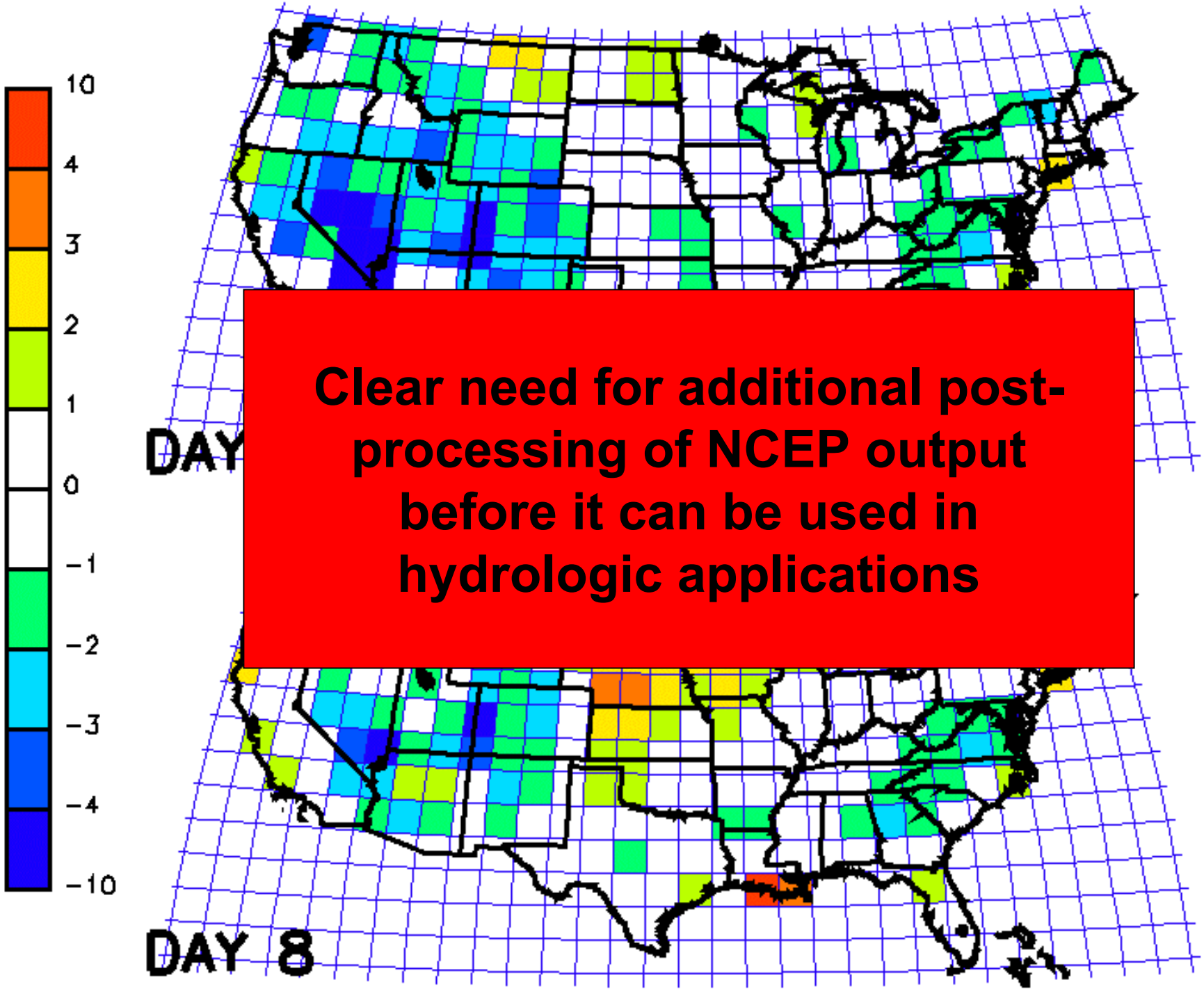
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Clear need for additional post-processing of NCEP output before it can be used in hydrologic applications

THE CDC-SCRIPPS RE-FORECAST EXPERIMENT

- Uses a fixed version (circa 1998) of the NCEP operational MRF.
- Ultimate goal – to generate an ensemble of eleven 21-day forecasts for the past 23 years (1978-2001), initialized with boundary conditions from the reanalysis project
- Control run already completed.

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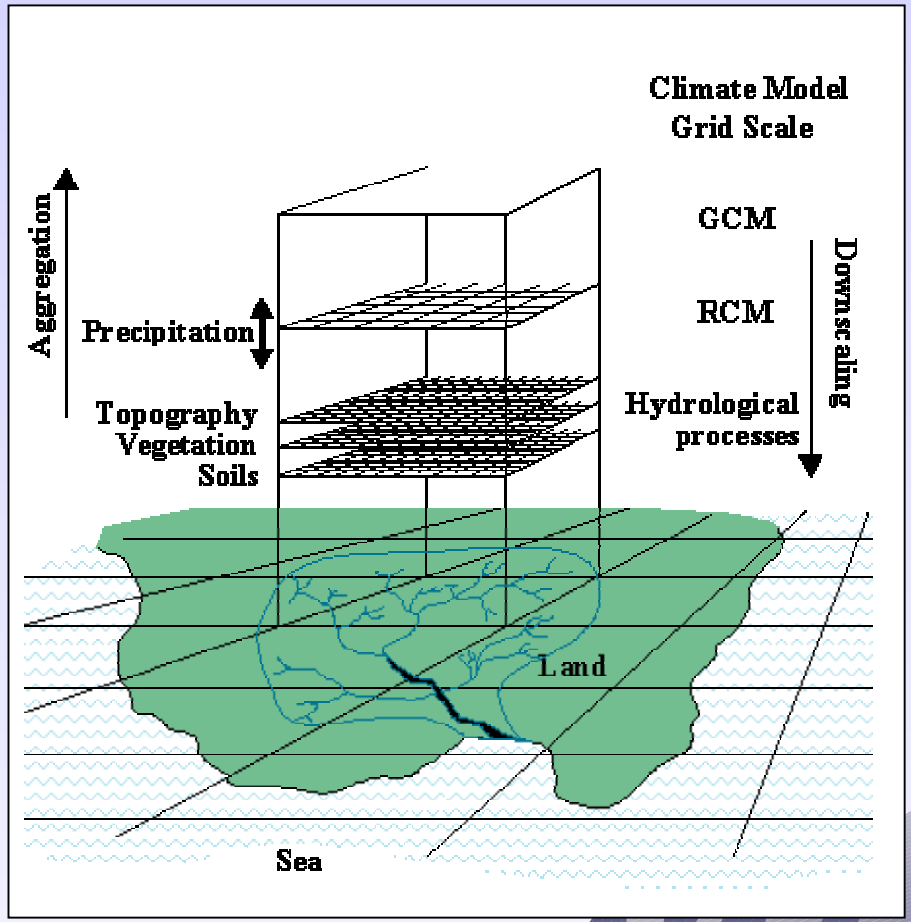
DOWNSCALING OF THE NCEP MRF OUTPUT

- **Use Multiple linear Regression with forward selection**
- **Predictor Variables (over 300):**
  - Geo-potential height, wind, and humidity at five pressure levels
  - Various surface flux variables
  - Computed variables such as vorticity advection, stabilitiy indices, etc.
  - Variables lagged to account for temporal phase errors in atmospheric forecasts.
- **Predictands are maximum and minimum temperature, precipitation occurrence, and precipitation amounts**



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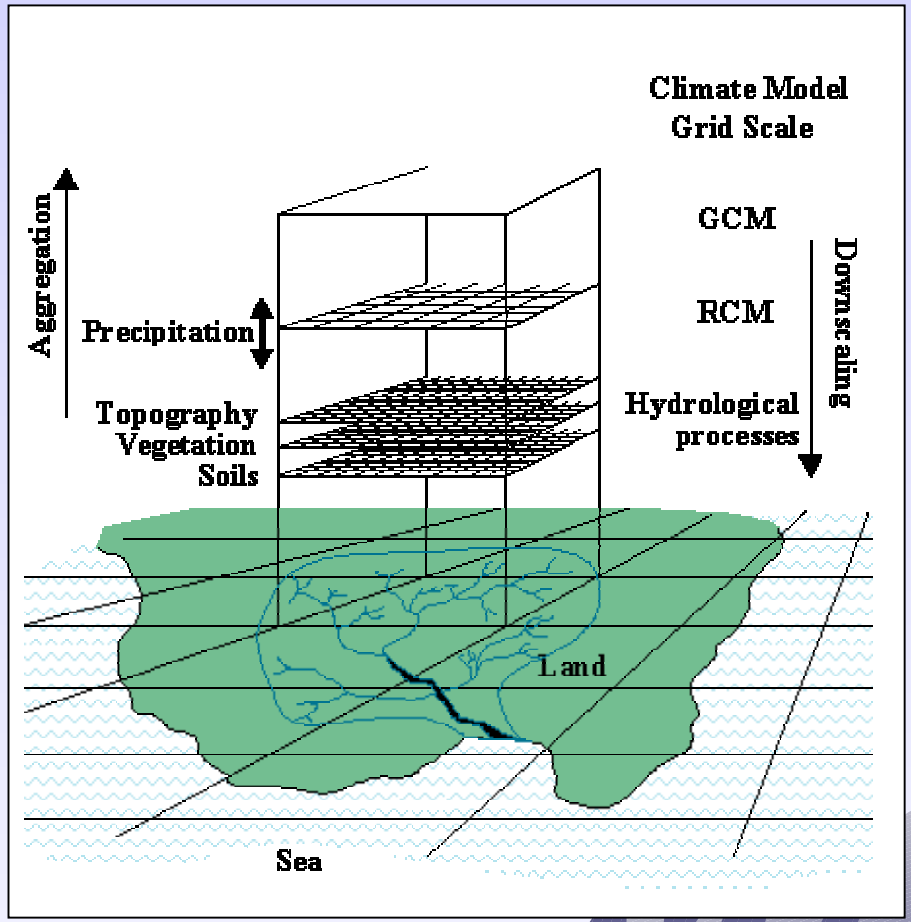
- **Stochastic modeling of the residuals in the regression equation to provide ensemble time series**



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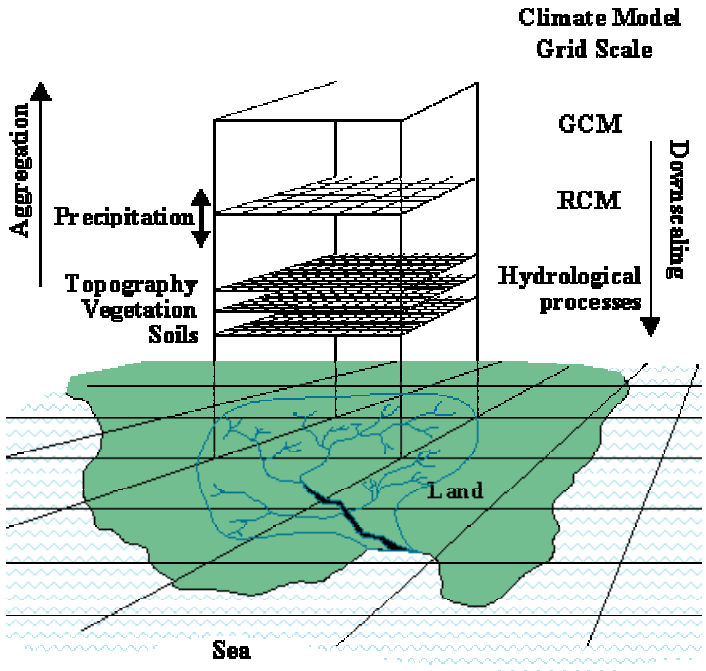
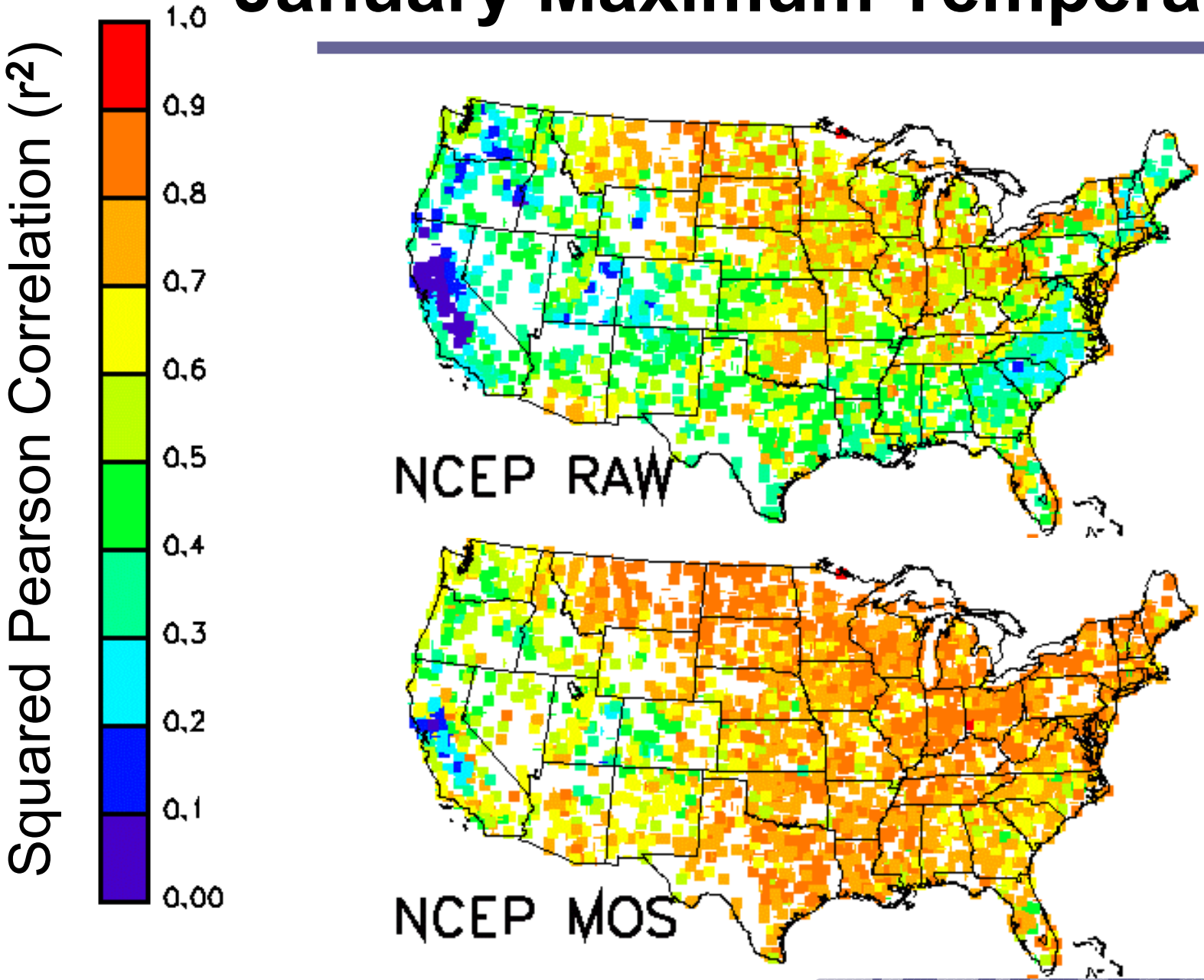
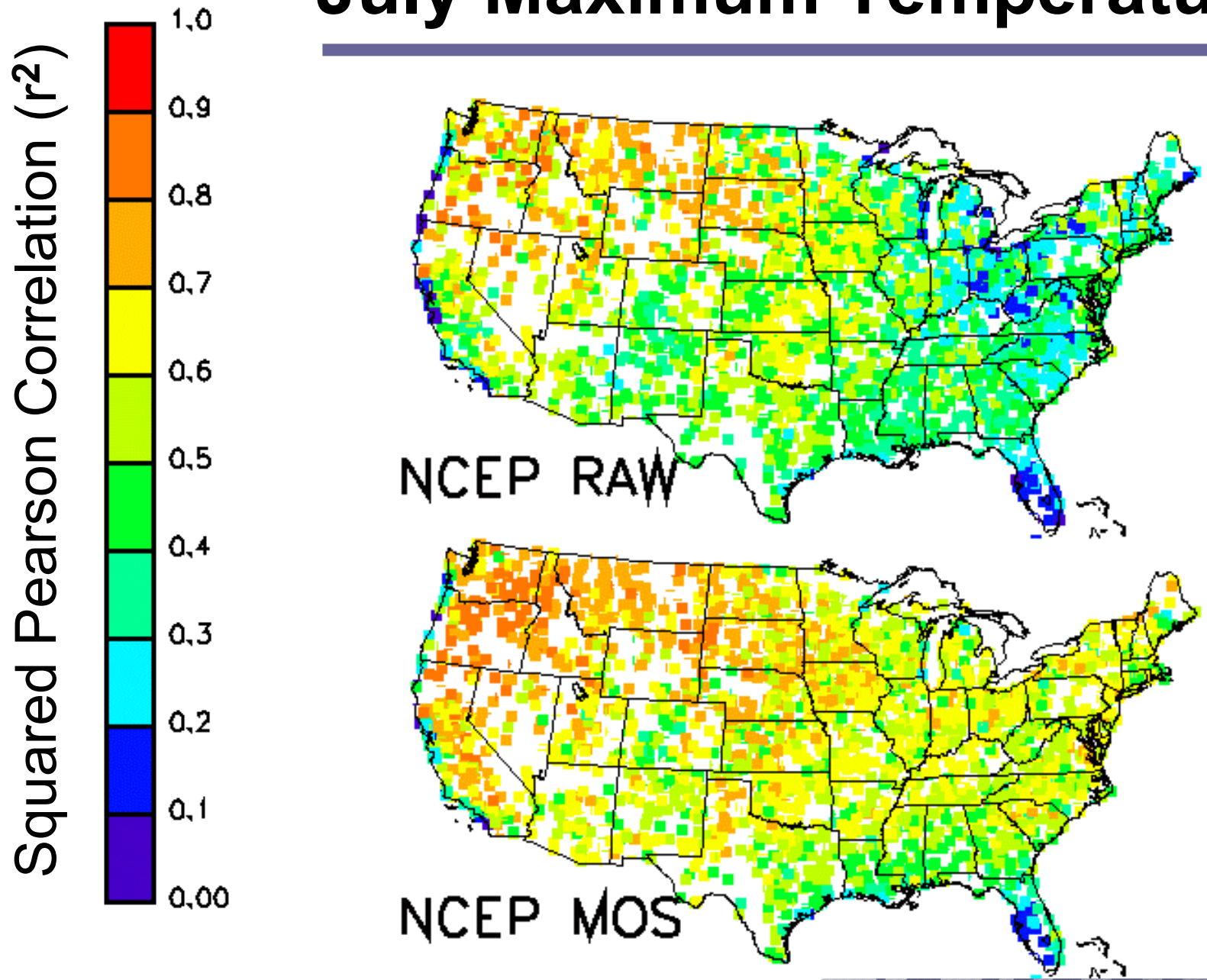


- **A separate equation is developed for each station, each forecast day, and each month.**
- **Equations developed over the period 1958-1976, and validated for the period 1977-1998.**

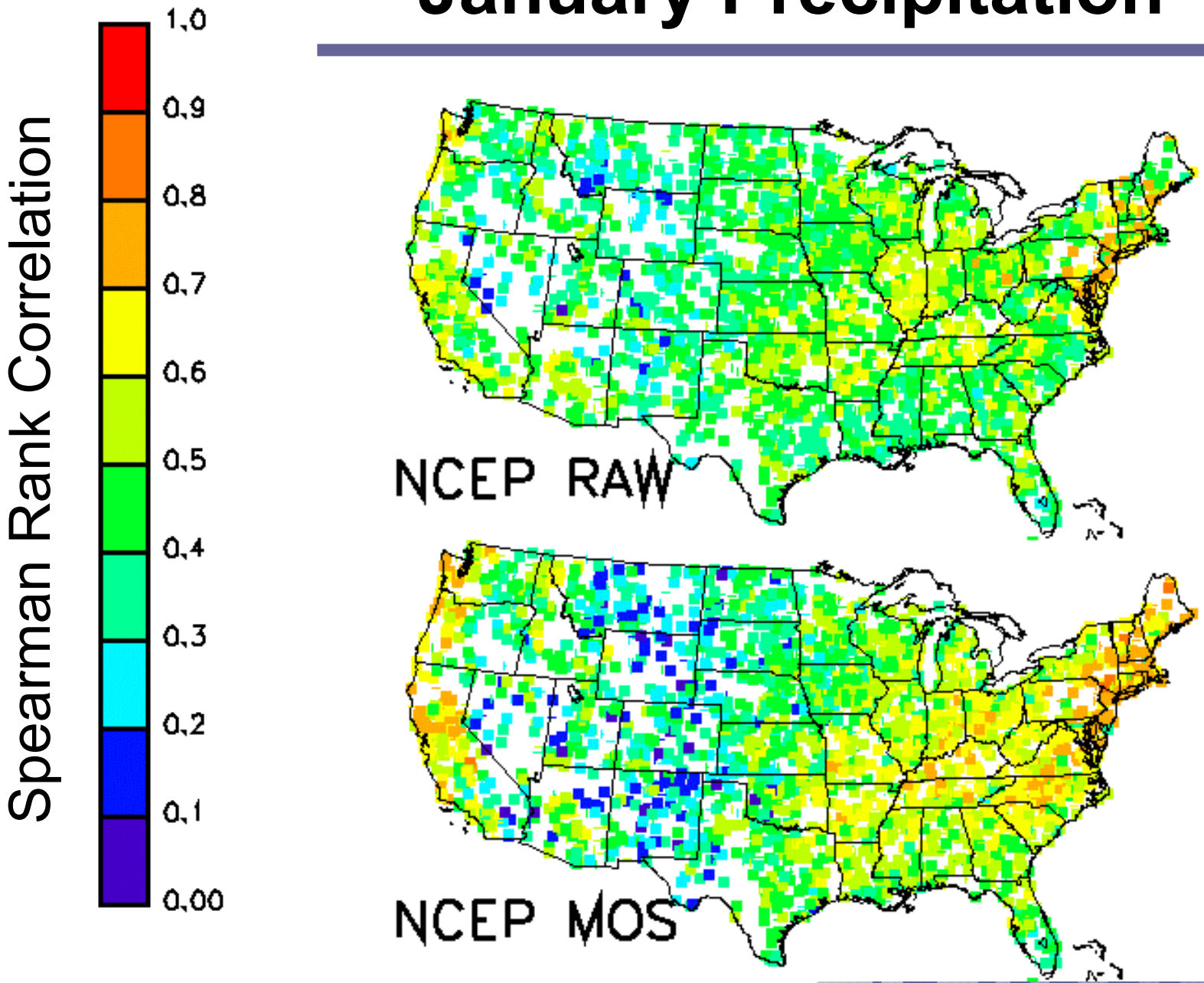
January Maximum Temperature



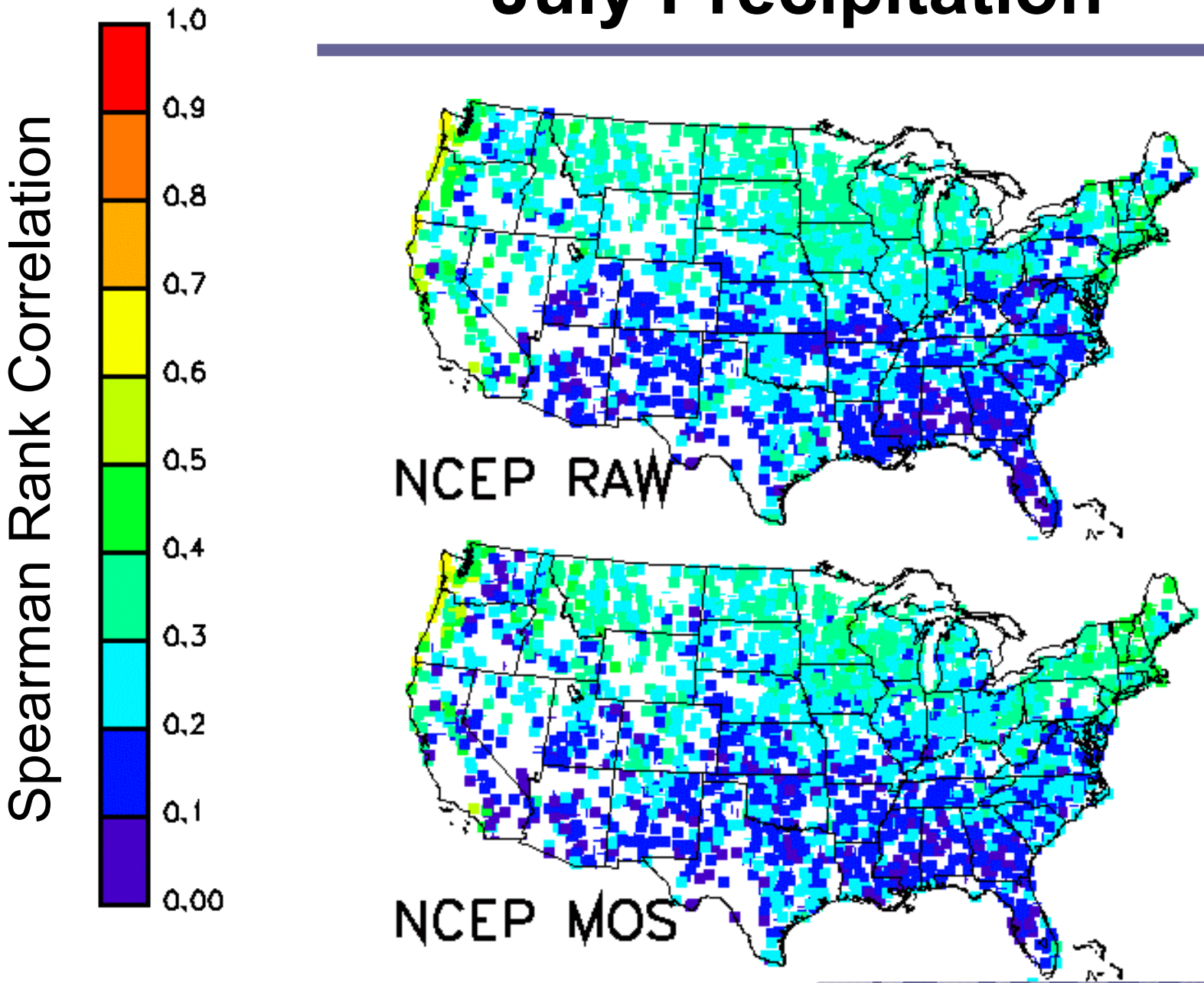
July Maximum Temperature



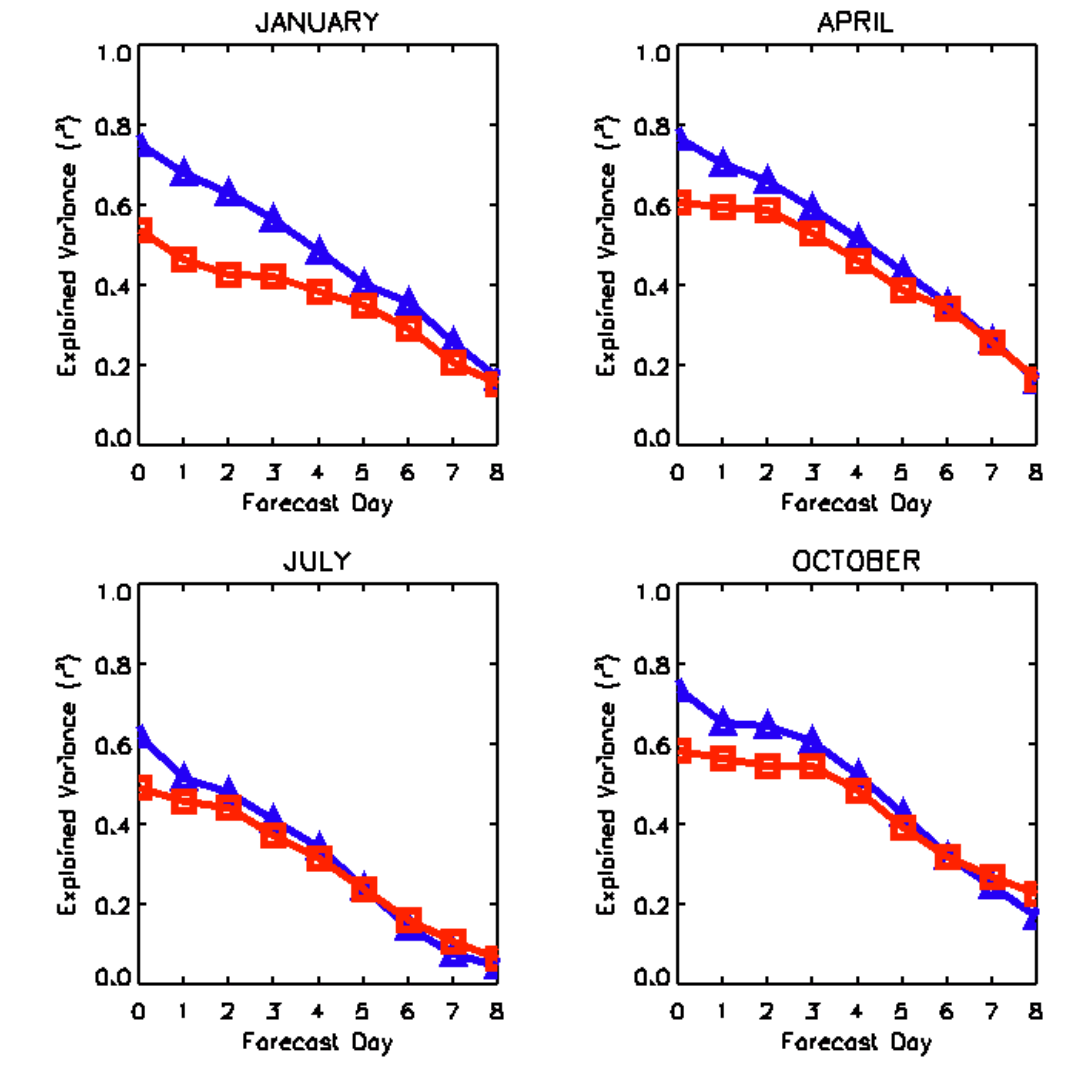
January Precipitation



July Precipitation

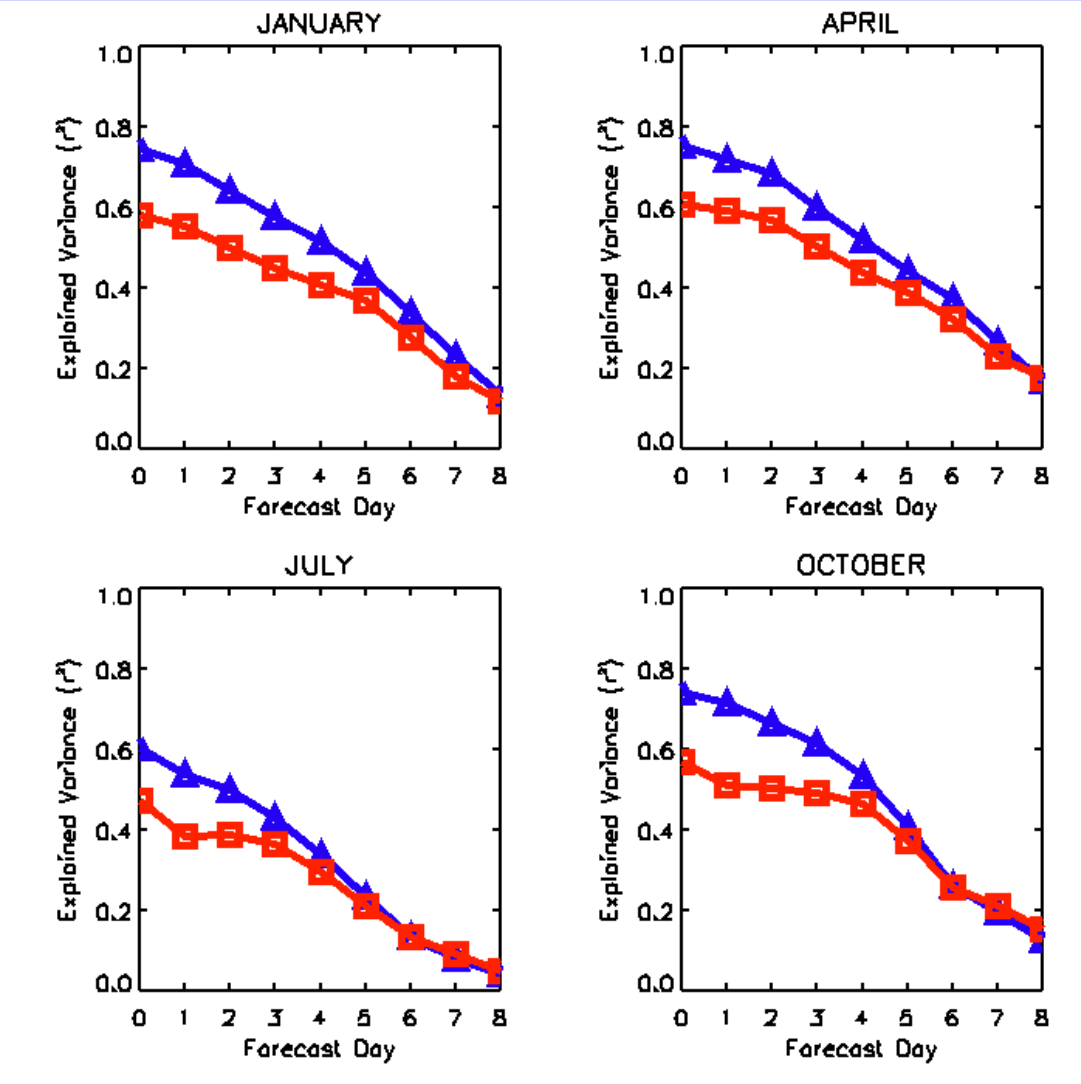


SKILL OF MAXIMUM TEMPERATURE PREDICTIONS



- Median explained variance of maximum temperature predictions, computed for the 11,000 NWS co-op stations.
- Red is raw NCEP predictions, blue is based on MOS guidance.

SKILL OF MINIMUM TEMPERATURE PREDICTIONS



- Median explained variance of minimum temperature predictions, computed for the 11,000 NWS co-op stations.
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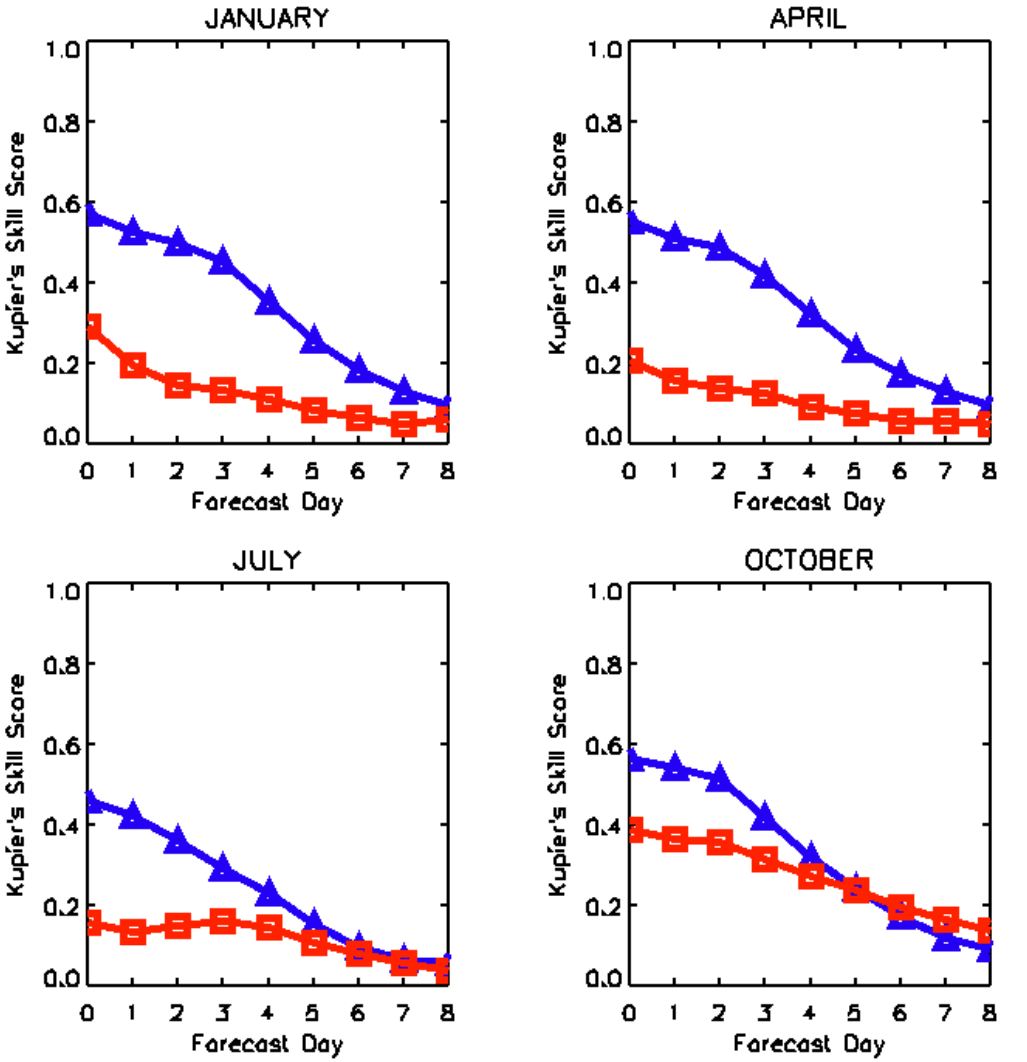
SKILL OF PRECIP OCCURRENCE PREDICTIONS



- Median explained variance of precipitation occurrence predictions, computed for the 11,000 NWS co-op stations.
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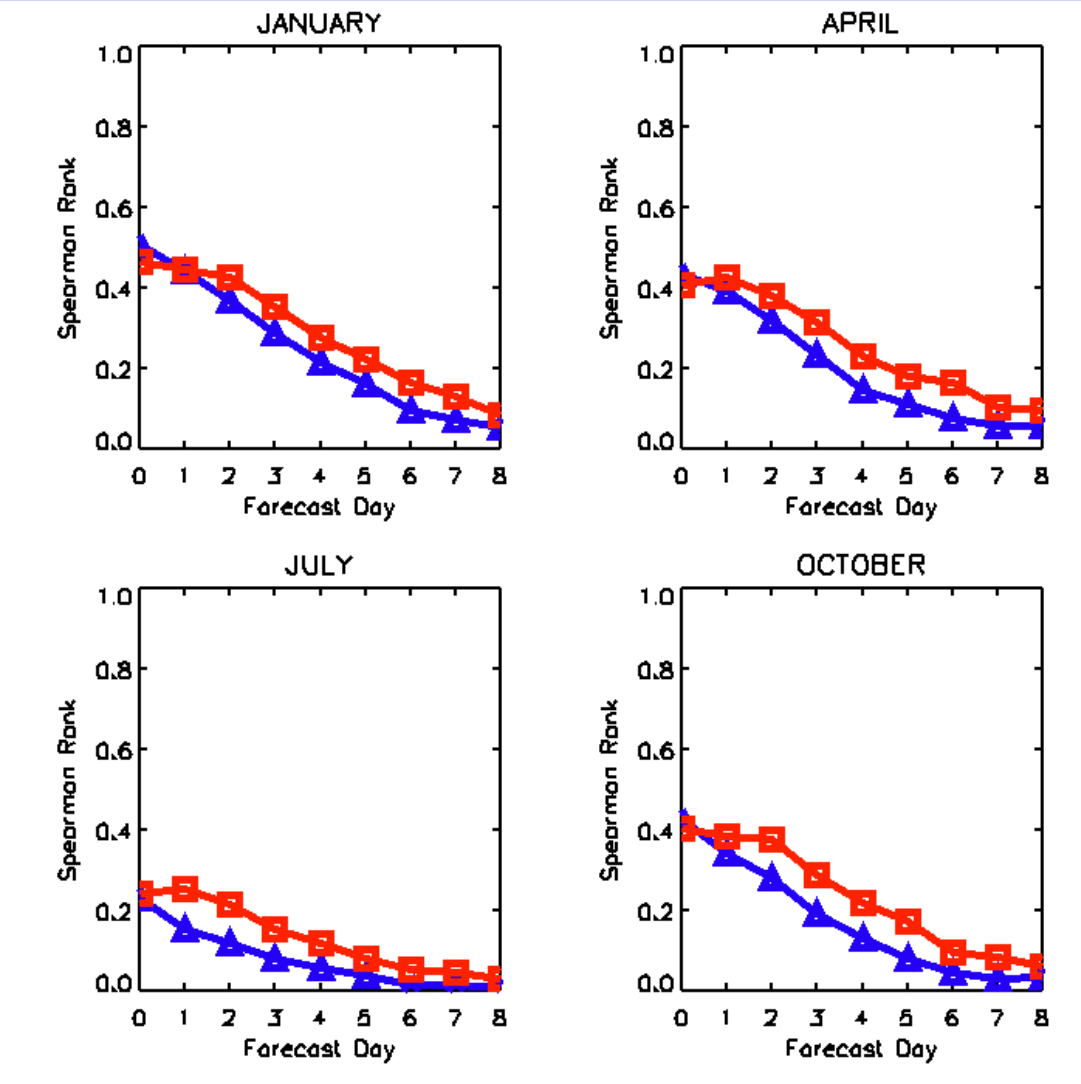
SKILL OF PRECIPITATION PREDICTIONS



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INTRASEASONAL HYDROLOGIC FORECASTS

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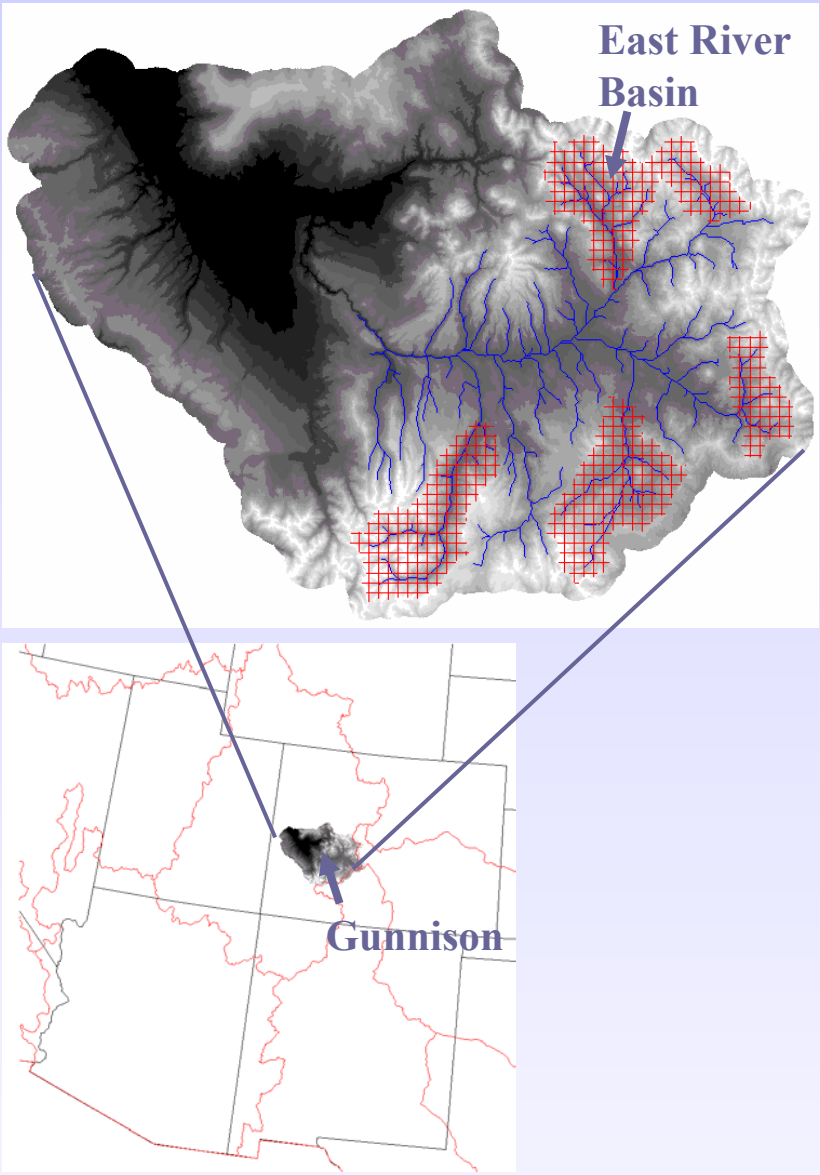
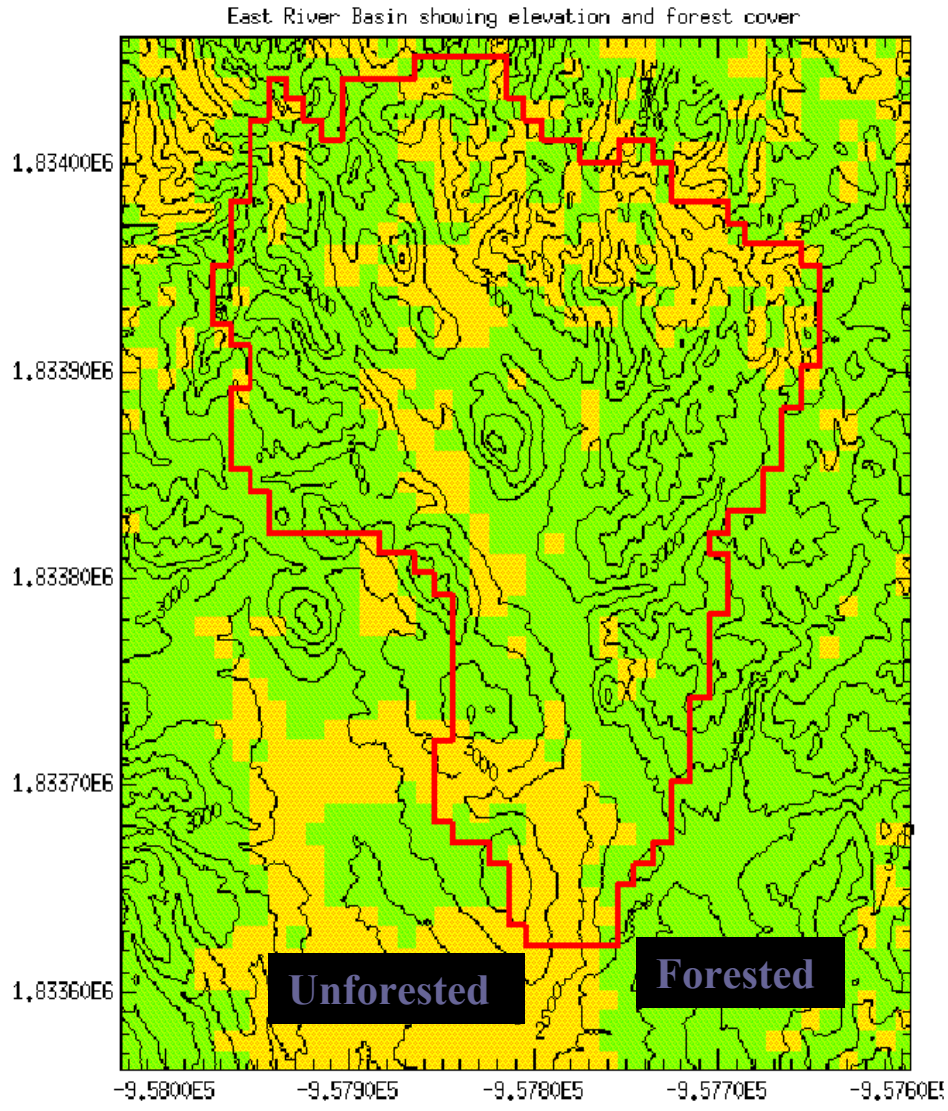
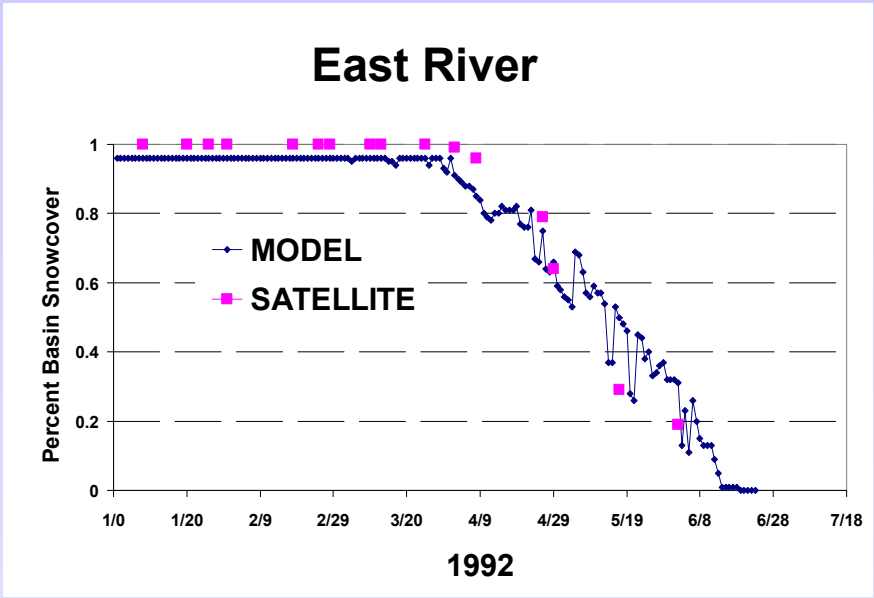
INITIAL STUDY AREA



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Percent Basin Snowcover
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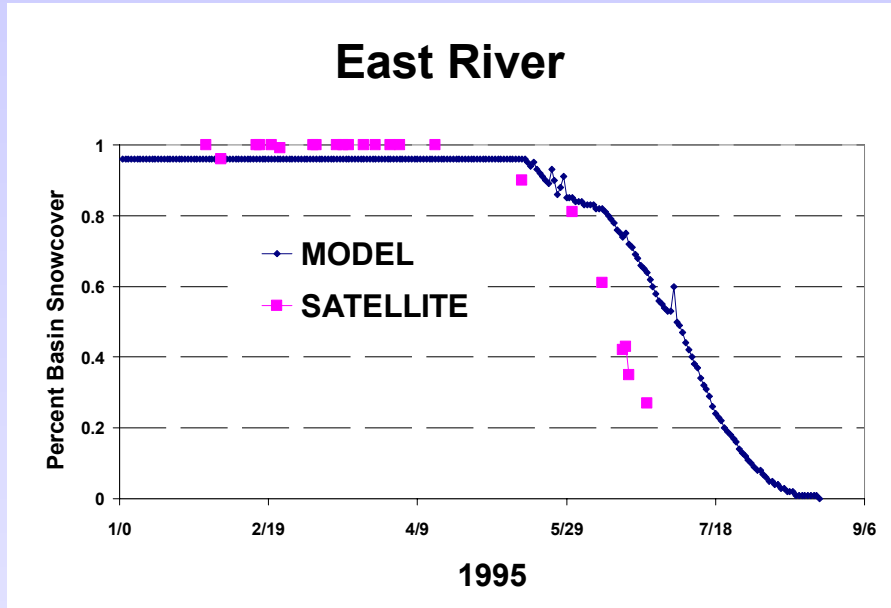
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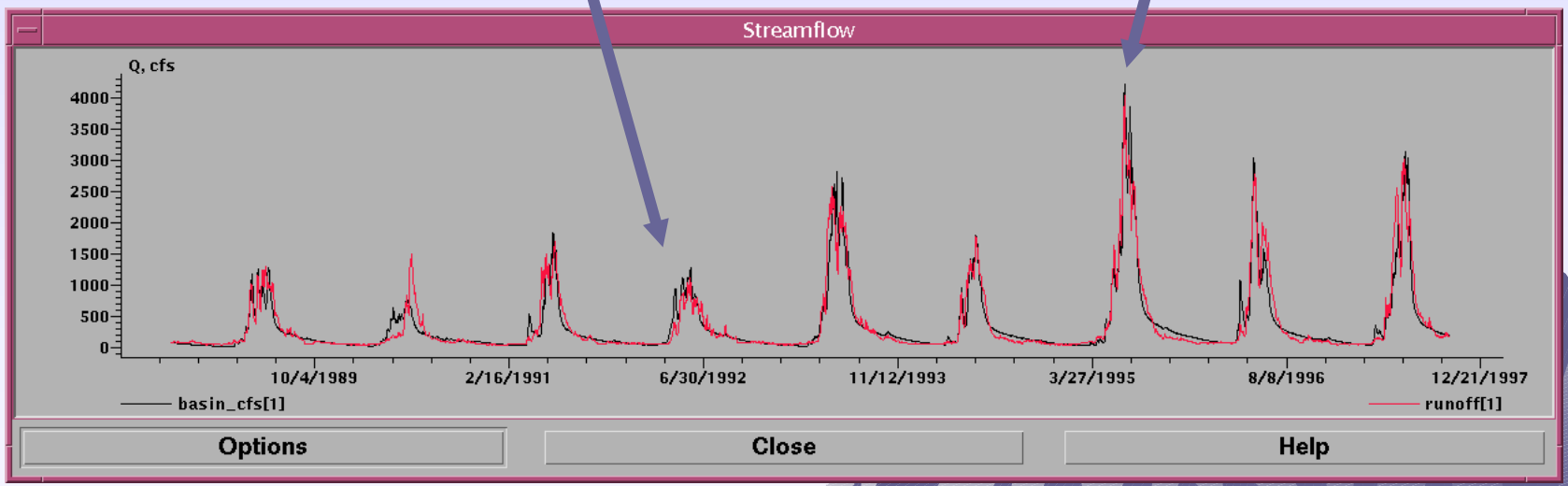
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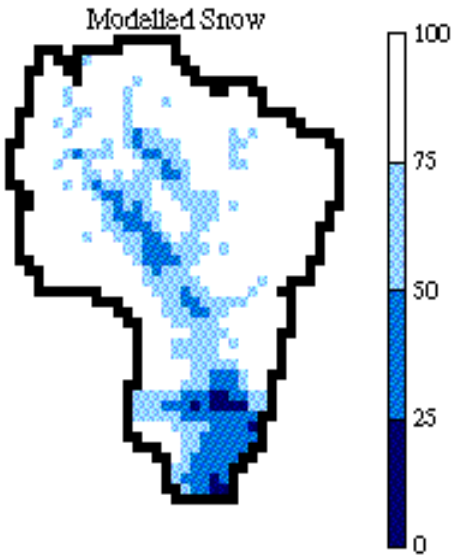
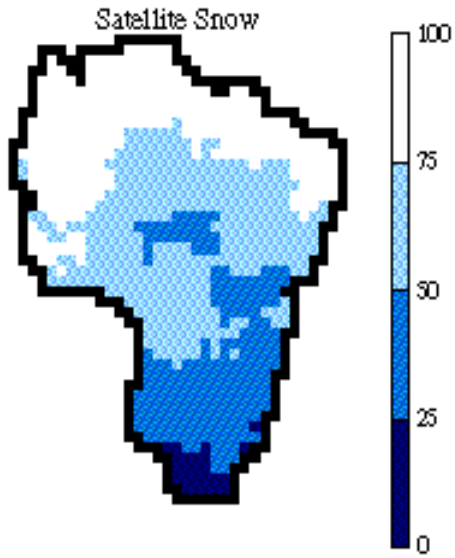
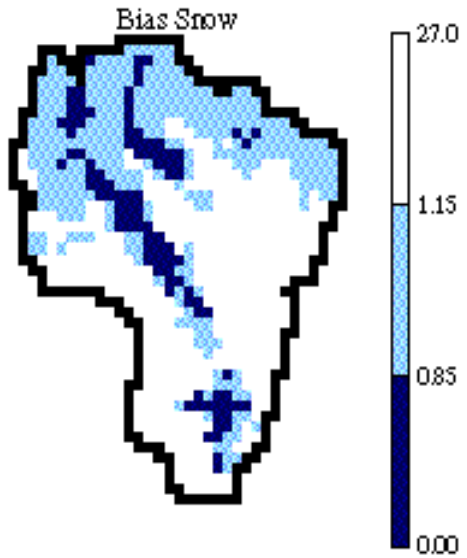
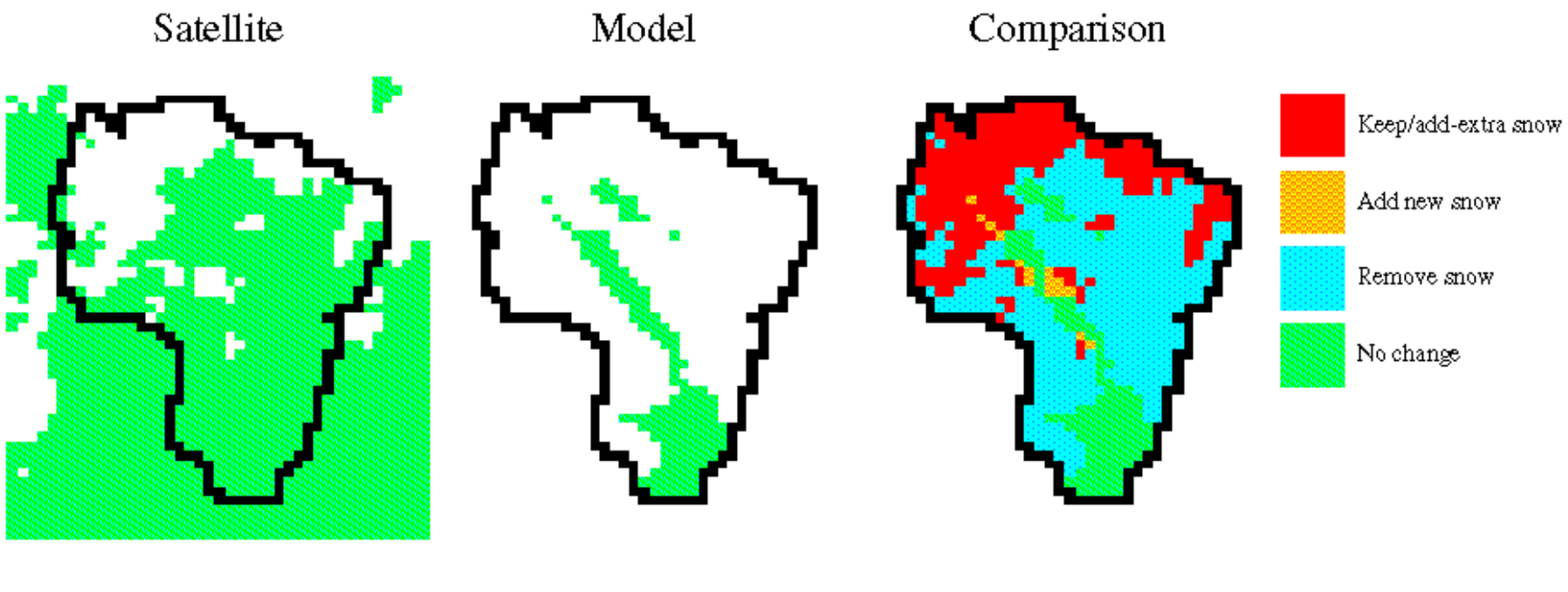
AVERAGE SPATIAL DISTRIBUTION OF SNOW COVER AND BIAS







COMPARISON OF SATELLITE- AND MODEL-DERIVED SNOW COVER MAPS



NOHRSC satellite-derived and model snow maps for 2 June 1997, and the results of a comparison of these maps.

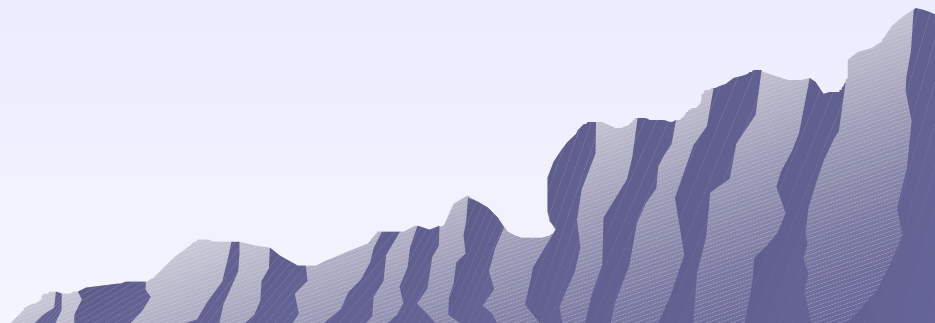
INTRASEASONAL HYDROLOGIC FORECASTS

Generate an archive of atmospheric forecasts

Develop downscaling relationships, and apply to the operational forecast model

Estimate basin initial conditions

Run hydrologic models in ensemble mode to provide probablistic forecasts of streamflow and estimates of forecast uncertainty



MULTI-MODEL SUPER-ENSEMBLES IN HYDROLOGY

Two Hypotheses:

- **The mean of runoff simulations from multiple models will be superior to the runoff simulation from any given model**

- **The spread of the hydrologic model ensemble is related to the error in the hydrologic simulation**

SUMMARY AND OUTLOOK

- The large biases in output from medium range forecast models creates a need for post-processing of model output in order for it to be effectively used in hydrologic simulations.
- Our downscaling system is successful in both removing mean model biases, and improving the skill in the raw NCEP output.
- When the downscaled NCEP output is used as input to hydrologic models, forecasts of runoff have greater skill than the forecasts generated with the traditional ESP approach.